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A Field Study of Tide-Induced Sand Movement on Del Monte Beach, California.

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A FIELD STUDY OF TIDE-INDUCED SAND MOVEMENT ON DEL MONTE BEACH, CALIFORNIA

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A FIELD STUDY OF TIDE-INDUCED SAND MOVEMENT ON DEL MONTE BEACH, CALIFORNIA

by

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ABSTRACT

Beach-elevation measurements were made and sand samples were collected daily along a profile extending from the back of the beach out to a water depth of approximately 23 feet. Wave and tide data were measured continuously at the site. The beach is well sheltered, and low swell parallel to the beach predominates.

Offshore-onshore movement of the plunge point by the tides exerts a large influence on the textural parameters which move on and off shore with the moving plunge point. The magnitude of textural parameter values increases with decreasing wave steepness. It appears that transport of large sand grains by wave and tide action produces the observed textural patterns.

Profile changes are greatest during mid-tide stages when the water level and position of the plunge point are changing rapidly.

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1. Background and Objectives

Many investigations of sand movement on natural beaches have been made previously. Most of these were characterized by long sampling intervals and incomplete wave data (Bascom, 1953; Inman, 1953; Trask and Johnson, 1955; Inman and Rusnak, 1956; Trask, 1959). However, at least three studies have been made with sampling intervals of several hours or less (Inman and Filloux, 1960; Strahler, 1964; Ingle, 1966), but these were of very short duration. A once-daily sampling interval extending over a period of about two months has been used with some success (Rohrbough, Koehr, and Thompson, 1964; Harlett, 1967).

The study by Harlett, which is limited to the intertidal portion of the beach, is probably the most comprehensive to date in relating beach profiles and sand properties to changing wave properties. However, the major shortcoming of his study is the fact that it did not include the surf zone which is the portion of the beach profile that undergoes the most turbulent water motion, and which this investigator believes to be the area of greatest sand movement along the beach profile.

The objective of this field investigation was, in effect, to extend Harlett's work by studying the behavior of the entire beach. To accomplish this, sand samples and profile measurements were taken daily at the same location studied by Harlett, and wave action was recorded continuously. Initially the plan of investigation was to

relate changes in the beach profile and in sand properties, empirically to changing wave parameters. Early examination of the field data revealed that sand properties were closely related to the outermost breaker point or plunge point of the waves. Therefore the objective was shifted mainly to investigating the relationships between sand properties and the location of the plunge point, which moves with the changing tide level.

2. Geographical Description of the Area

a. Del Monte Beach

The beach profile studied is located on Del Monte Beach in the southern end of Monterey Bay, California (Figure 1). The inner shoreline of the bay is, for the most part, one long continuous sand beach from Santa Cruz to Monterey Harbor. Immediately adjacent to the harbor, the sand beach gives way to a rocky shore.

The exposed portion of Del Monte Beach has a slope of about 1:20. It is composed of medium-to-fine siliceous sand in which the dominant minerals are quartz, quartzite, and feldspar. Under some surf conditions, cobbles two to three centimeters in diameter are deposited sparsely on the beach. The field investigation was made about one-half mile from Monterey Wharf No. 2.

b. Wave and Tide Conditions

The location of Del Monte Beach and the offshore topography of Monterey Bay are such that nearly all waves entering the bay from the open ocean are refracted

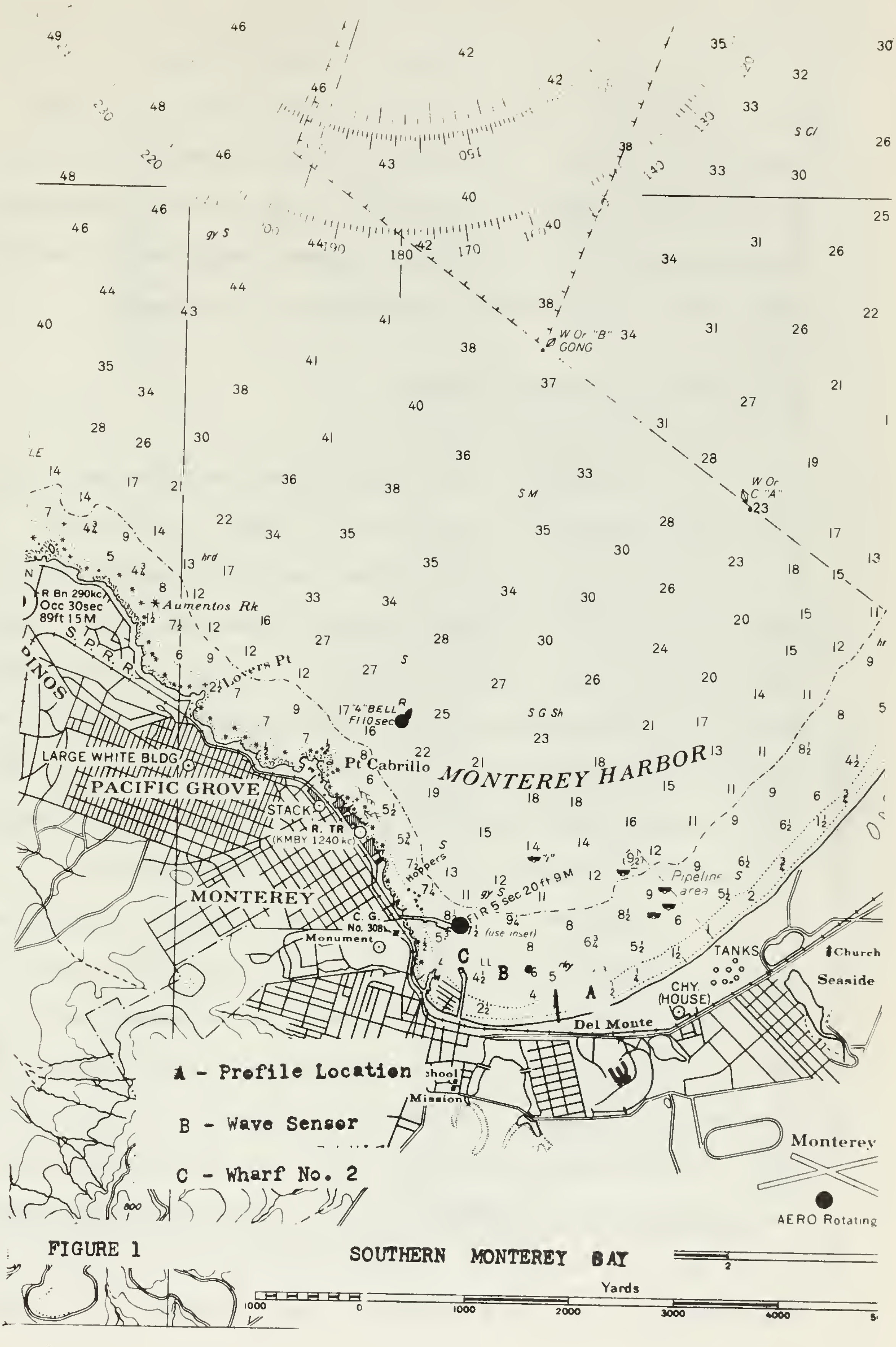


FIGURE 1 SOUTHERN MONTEREY BAY

so as to arrive as low swell with their crests parallel or nearly parallel to shore. Plunging breakers are the most common, and wave heights normally do not exceed three feet. Surf intensity increases toward the north as the ocean exposure increases. The tides in Monterey Bay are mixed, and the range between Mean Lower Low Water (MLLW) and Mean Higher High Water is 5.3 feet.

3. Measuring and Sampling

a. Sampling Stations

Sand level measurements and samples were taken along the profile at the stations shown in Figure 2. Stations 27-46 consist of railroad rails (hereafter called the "rail line" or "rails") driven into the sand. These are the same rails used by Harlett in his investigation. Rail 46 was designated as the reference rail and all distances along the profile were measured relative to this rail. These rails were last surveyed and their elevations relative to MLLW established on 14 January 1968.

Stations 101 and 1-26 were placed in position for use in this investigation. These stations consisted of a three-foot flexible buoyant line attached to a 16-inch metal corkscrew which was screwed into the bottom (Figure 3). Stations 11-26 were placed at 10-foot intervals through the surf zone. Past the surf zone little sand movement was expected so the interval between stations was increased to 20 feet. Station 101, a sand sample station only, was placed 40 feet seaward of station 1.

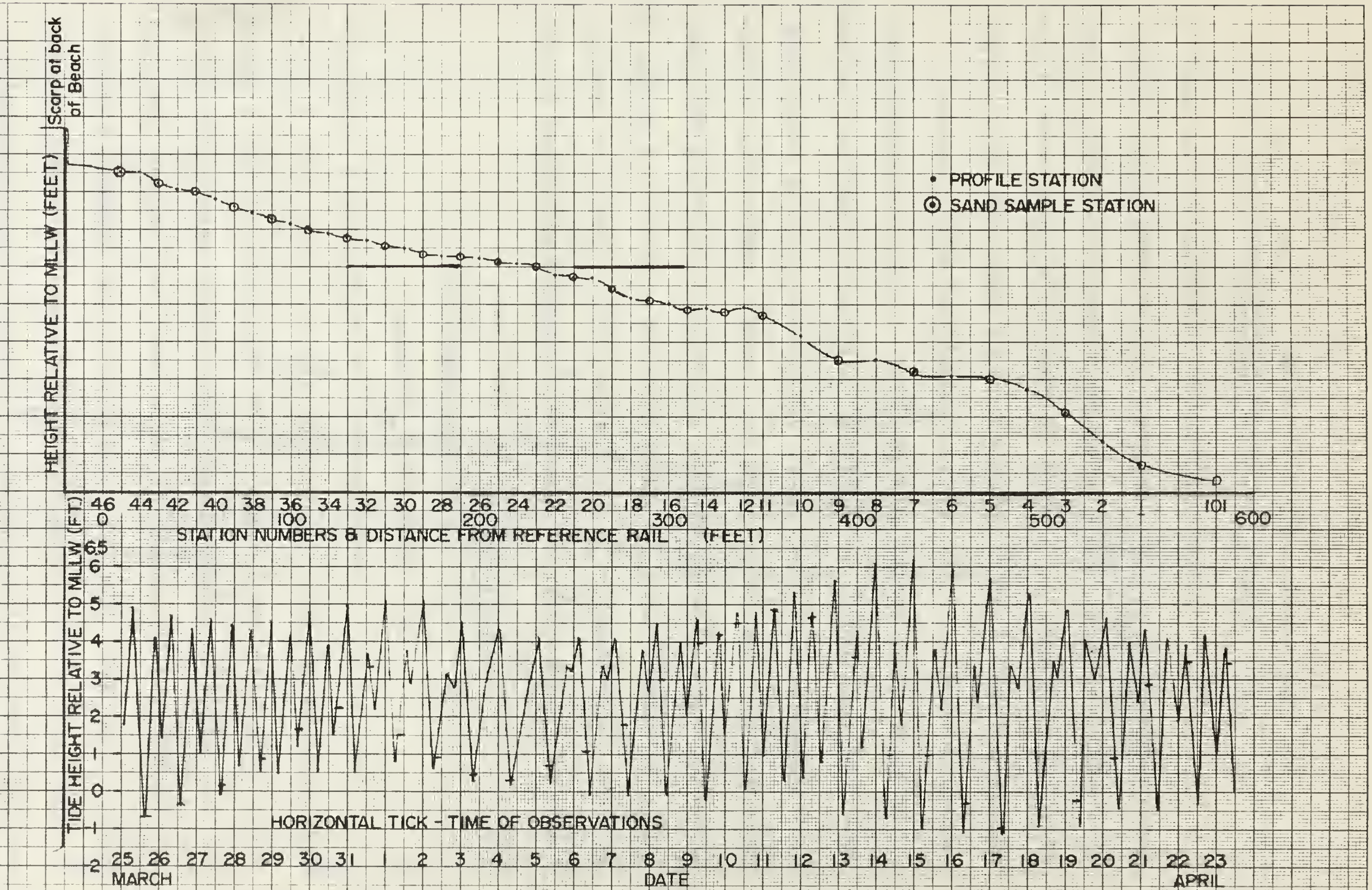


FIGURE 2 Station Locations & Times Of Observations

b. Measuring and Collecting

(1) Difficulties Encountered

A major difficulty encountered was that of taking measurements and samples in the surf zone. Even with the low waves that occurred during the study, it was difficult to work in a zone 20 feet on either side of the plunge point. Just outside the surf zone the wave surge caused movement of the divers (equipped with standard SCUBA gear with additional weights to aid in maintaining position) of from 5 to 10 feet in either direction as each wave passed. The underwater visibility during the study ranged from eight feet to a few inches, depending on distance from the plunge point. To aid in locating the stations systematically, a guide line was installed along the profile from Station 21 to Station 101. The line was allowed to float clear of the profile and was marked at the same intervals as the profile stations.

(2) Profile Measurements

(a) Measuring Methods

Measurements of sand levels along the rail line were made relative to the rail top with a two-meter long, T-shaped staff. The cross arm of the T allowed the staff to bridge scour depressions around the base of the rails. The readings were made by placing the staff against the rail and sighting across the highest portion of the rail to the horizon. This method was used on the exposed portion of the beach or whenever wave conditions

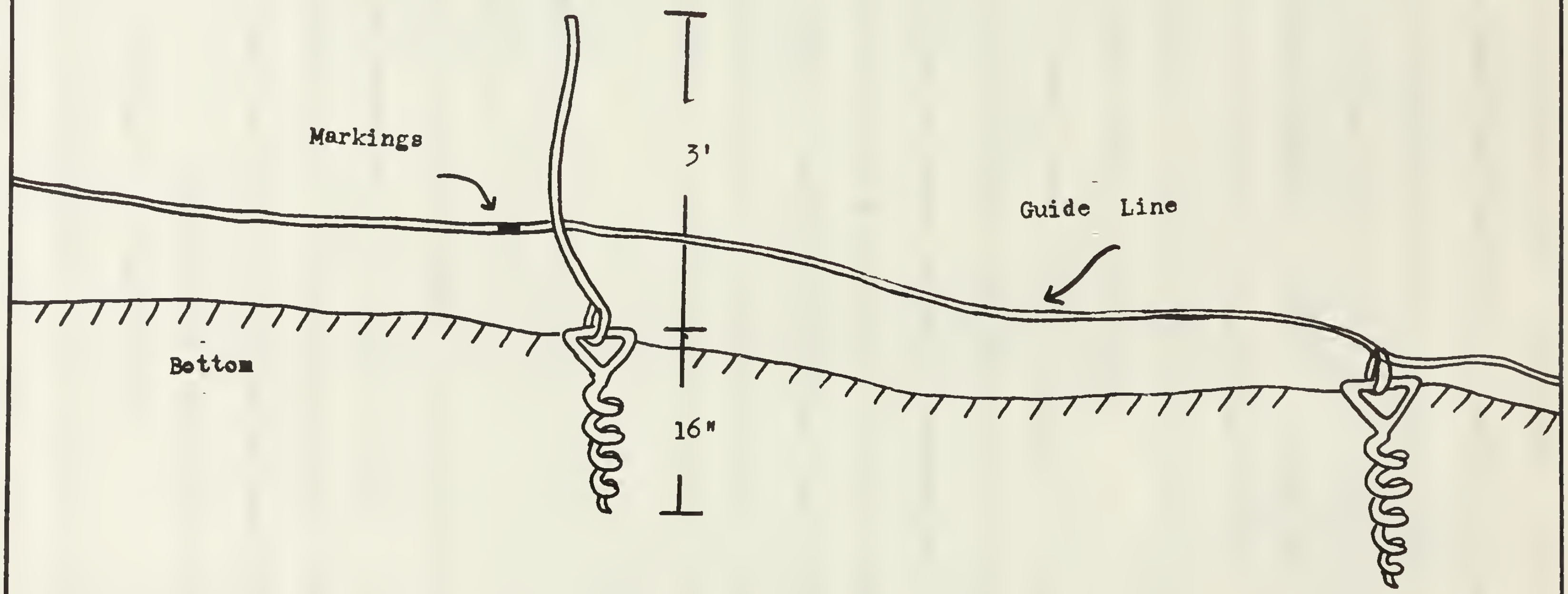


FIGURE 3 UNDERWATER PROFILE MEASURING STATION

were quiet enough to allow it. When waves were moving past the rails, the staff could not be left in place more than a moment or two, otherwise the sand would erode from under the staff and erroneous readings would be obtained. Under these conditions, the staff would be placed against the rail, the height quickly marked, and the staff removed and read. Under the worst conditions, the readings were considered accurate to the nearest centimeter.

Sand-level measurements at the seaward stations (Stations 1-26) were made using a one-meter long T-shaped staff made of a metal rod with a meter stick attached. Measurements were made by pulling the buoyant line (Figure 3) to a vertical position, placing the staff next to the line, and reading the distance from the seafloor to the top of the line. No difficulties were encountered in taking measurements in water depths greater than 15 feet.

(b) Conversion of Measurements

The staff readings taken on the rail line gave the distance from the top of each rail to the sand level. Table 1 gives the measured elevation of the rails. The actual elevation of the sand at a rail relative to MLLW was obtained by subtracting the reading at the rail from the rail elevation.

The absolute seafloor elevations at the offshore stations were obtained in the following way. On a day when the waves were low (11 April), water-depth

TABLE I

Profile Reference Elevations

Rails: Station Number	Rails: Elevation of top of Rail Relative to MLLW (feet)	Measuring Lines: Station Number	Measuring Lines: Elevation of top of Measuring Line Relative to MLLW (feet)
46	14.27	26	-18.20
45	13.77	25	-15.52
44	12.47	24	-12.35
43	10.70	23	- 9.91
42	(rail missing)	22	- 8.78
41	10.45	21	- 8.49
40	9.26	20	- 7.83
39	8.28	19	- 6.84
38	7.61	18	- 7.04
37	7.24	17	- 4.44
36	7.01	16	- 2.67
35	5.98	15	- 1.63
34	5.14	14	- 1.88
33	4.61	13	- 1.63
32	4.53	12	- 2.06
31	3.88	11	- 1.32
30	4.70	10	- .83
29	4.84	9	- .44
28	4.35	8	.22
27	6.09	7	.09
		6	1.72
		5	.41
		4	.93
		3	1.37
		2	1.94
		1	2.20

measurements were taken along the profile and were adjusted to MLLW (Table 2). Readings were taken at the same time of the distance from the sea floor to the top of the measuring lines, and were subtracted from the depth to give a reference depth to the top of each measuring line relative to MLLW (Table 1). By adding the staff readings taken at each station to the reference depth of that station, the daily sand level relative to MLLW was established.

(3) Sand Samples

Sand samples were difficult to take at the underwater stations. With the expectation that the sand at the very surface would reflect the wave conditions prevailing during the sample interval, care was taken to sample only the uppermost layer of sand. At first a small scoop designed for this study was used to collect the sand samples (Figure 4). The clear plastic top was used in order to be certain the scoop was empty prior to taking samples. The pouring spout at the end enabled the sample to be transferred to a collection bottle with no apparent loss of sample. However, use of the scoop proved impractical because working in the surf zone and collecting samples with the scoop under heavy surge action required more hands than were available. One half-pint, plastic refrigerator jars were substituted. The jar was scraped over the sand to obtain the samples, care being taken to ensure that the samples came from the topmost inch of the bottom.

TABLE 2

PROFILE DEPTH MEASUREMENTS ON 11 APRIL, 1968

Station Number	Depth Relative to MLLW (feet)
101	-23.0
1	-21.25
3	-15.5
5	-12.0
7	-11.0
9	- 8.8
11	- 5.0
13	- 3.0
15	- 3.0
17	- 1.5
19	- 1.0
21	- 0.8
23	0.0
25	0.5
27	1.0

Sand samples were collected at a position two or three feet to the side of the station at odd-numbered stations along the profile (Figure 2). Samples were not collected on the beach above the previous day's high water mark.

(4) Frequency of Observations

Sand samples and sand-level measurements were taken daily during the 30-day period from 25 March through 23 April 1968. From 25 March to 31 March the sampling time was 1400, but on 1 April the time was shifted to 0800 in the hope of finding better wave conditions in the morning. Surf conditions were such that underwater readings were not attempted on 6 April and 20 April. Partial profiles and samples were taken on some other days due to the surf action.

(5) Wave and Tide Records

Waves were recorded continuously by a Mark IX (Snodgrass) pressure-type sensor located 220 yards offshore from Rail 27 and about 30 yards off the profile line (Figure 1). The instrument is mounted on a tripod three feet above the bottom in 30 feet of water. The analog recorder is located at the Naval Postgraduate School, and during the field investigation it was set on a 10-foot height scale. The recorder was run at slow speed (3 inches per hour), with a five-minute fast trace (3 inches per minute) recorded every four hours. The slow trace portion of the record was used to obtain wave heights and

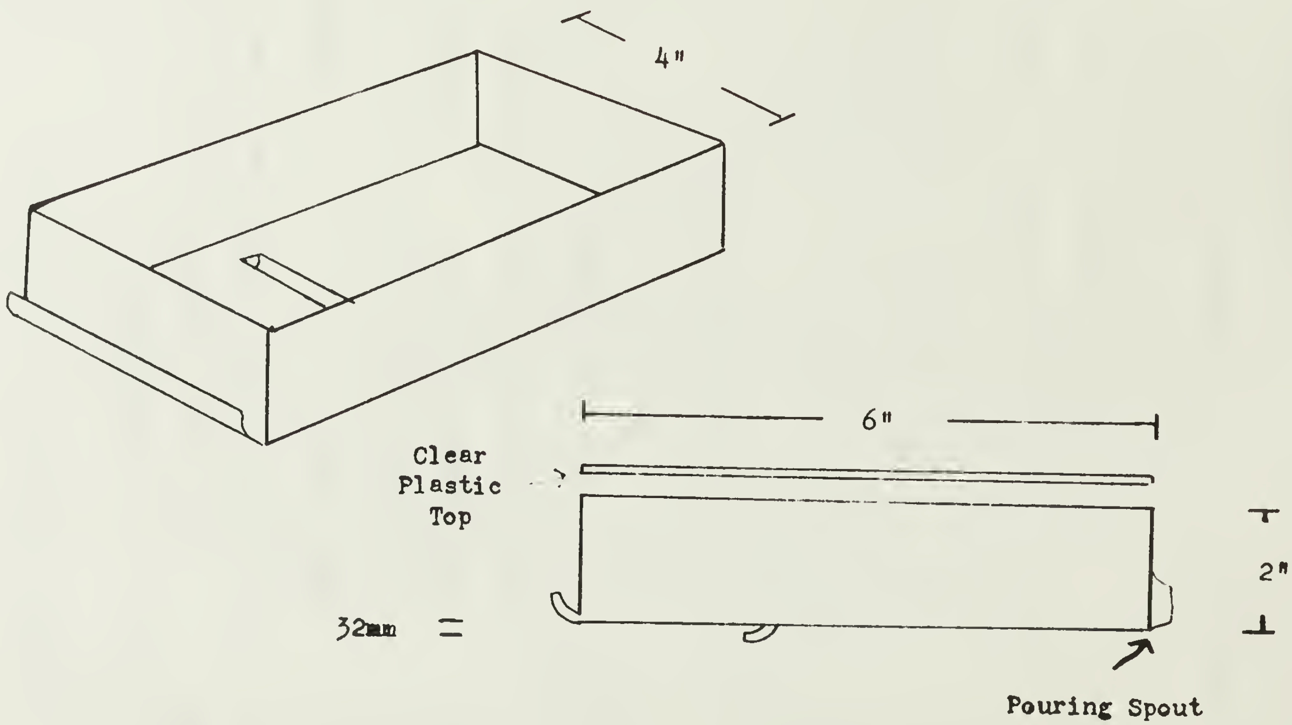


FIGURE 4 SAND SCOOP

the fast trace was used to determine periods. The wave recorder operated continuously during the study except for the period from 0800 on 11 April to 1400 on 12 April.

In addition, the location of the outermost breakers at the time of each daily observation was recorded with reference to the profile.

Tide information was taken from marigrams recorded on a standard tide gauge located on Monterey Wharf No. 2 (Figure 1). The tide gauge is operated by the Naval Postgraduate School.

The location of the plunge point, height of the tide, and wave heights at the time of observations are shown in Figure 5.

(6) Miscellaneous Observations

The existance of cusps at the time of the observations was recorded and the general dimensions and location relative to the rail line was noted (Appendix A). Cusps were present on 15 days. In general the rail line was the center of a swale. The cusps usually measured 100 feet from apex to apex. They occurred at the high-tide portion of the beach and always were subdued. Wind observations also were made daily at the time of the profile measurements (Appendix A).

4. Data Reduction

a. Profile Data

The daily sand level readings, made in centimeters, were converted to elevations in feet relative to

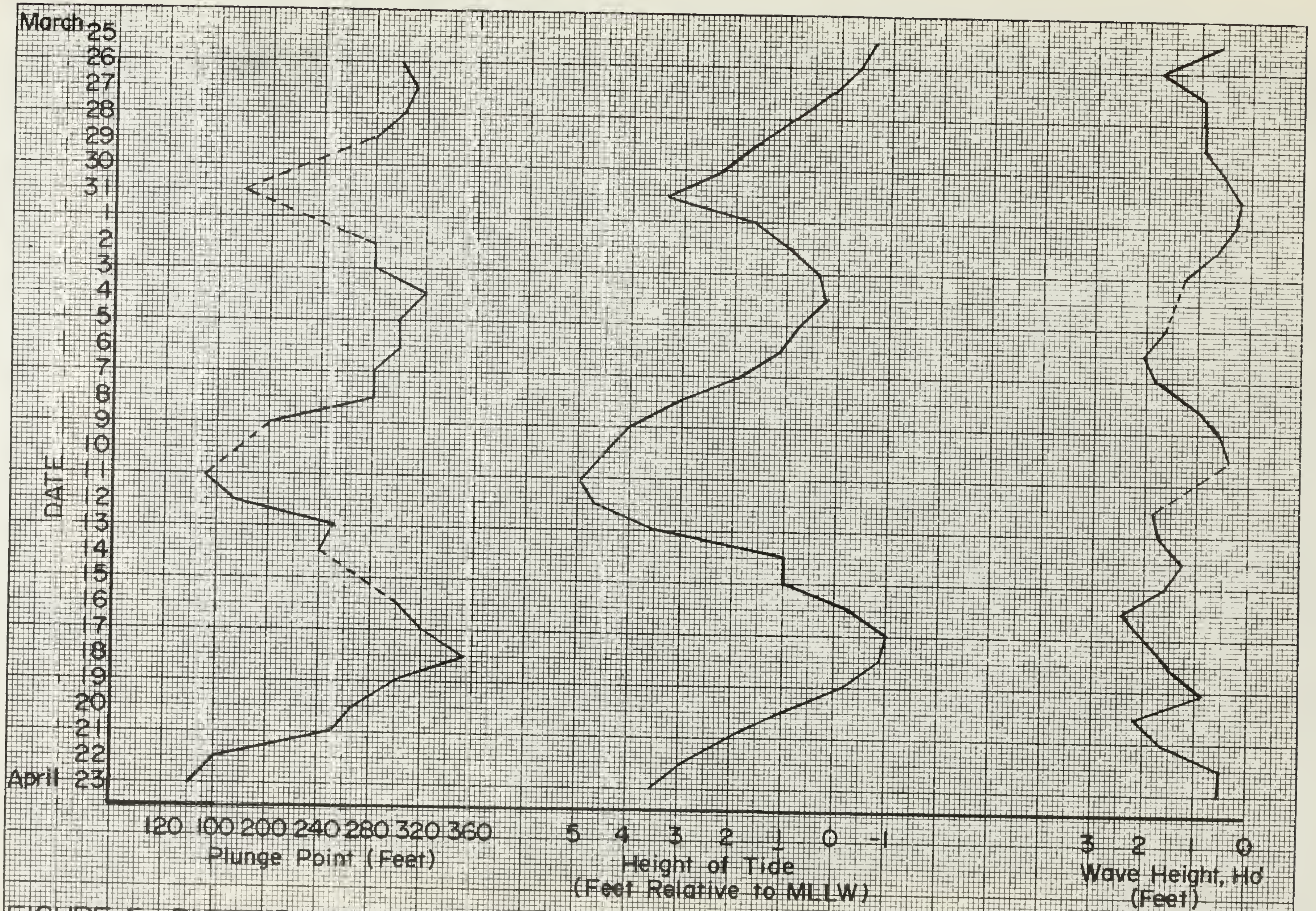


FIGURE 5 Plunge Point Location, Tide Height Wave Height At Time Of Observations

MLLW (Appendix B). Daily profiles were then plotted and are shown in Figures 6a through 6d. Daily profile changes are found in Appendix C.

b. Sand Properties

Of the 500 to 600 samples collected, 319 were selected for analysis so as to give a representative picture of the distribution of sand properties across the entire profile every day. The samples were dried at a temperature between 96 and 100 F, and were sifted on a mechanical shaker through a set of U. S. Standard Sieves having the following mesh diameters (in mm): 3.962, 1.981, 0.991, 0.495, 0.351, 0.246, 0.175, 0.124, 0.088, and 0.061. The cumulative weight of the sand coarser than each sieve size was then determined directly by reconstituting the sample fraction-by-fraction beginning with the coarsest fraction. A computer program then converted this to a cumulative distribution by percent and plotted the cumulative distribution curve. These curves were smoothed by hand and the grain diameters at the 95th, 84th, 50th, 16th, and 5th percentiles then were read. The diameters in millimeters were converted into phi units where, following notation by Inman (1952),

$$\phi = - \log d \,(\mathrm{mm})$$

The phi diameters were then used to compute the following parameters for each sample:

(1) Median Diameter, $M_{d\phi}$ the value of the 50th percentile.

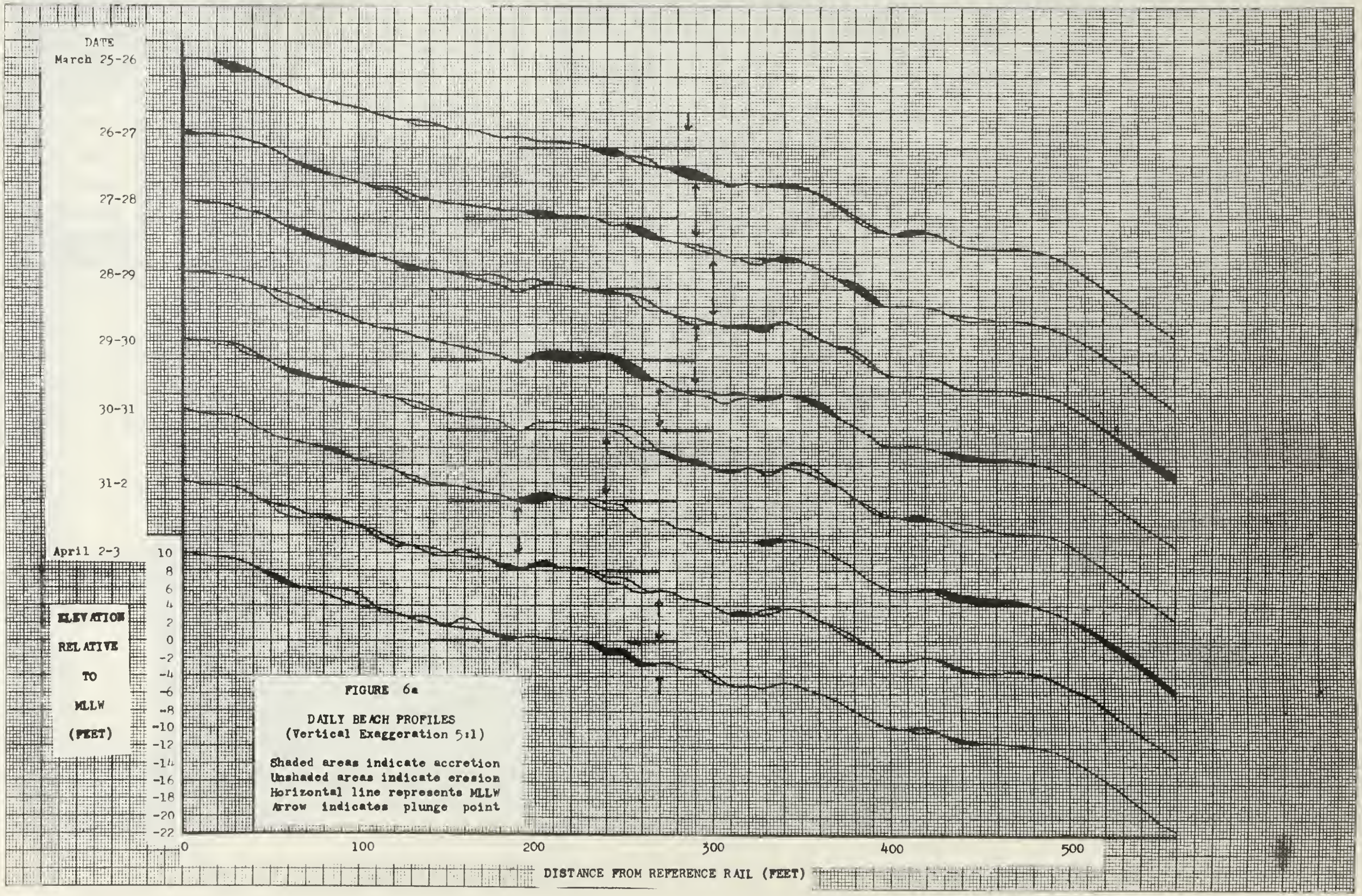


FIGURE 6a

DAILY BEACH PROFILES
(Vertical Exaggeration 5:1)

Shaded areas indicate accretion
Unshaded areas indicate erosion
Horizontal line represents MLLW
Arrow indicates plunge point

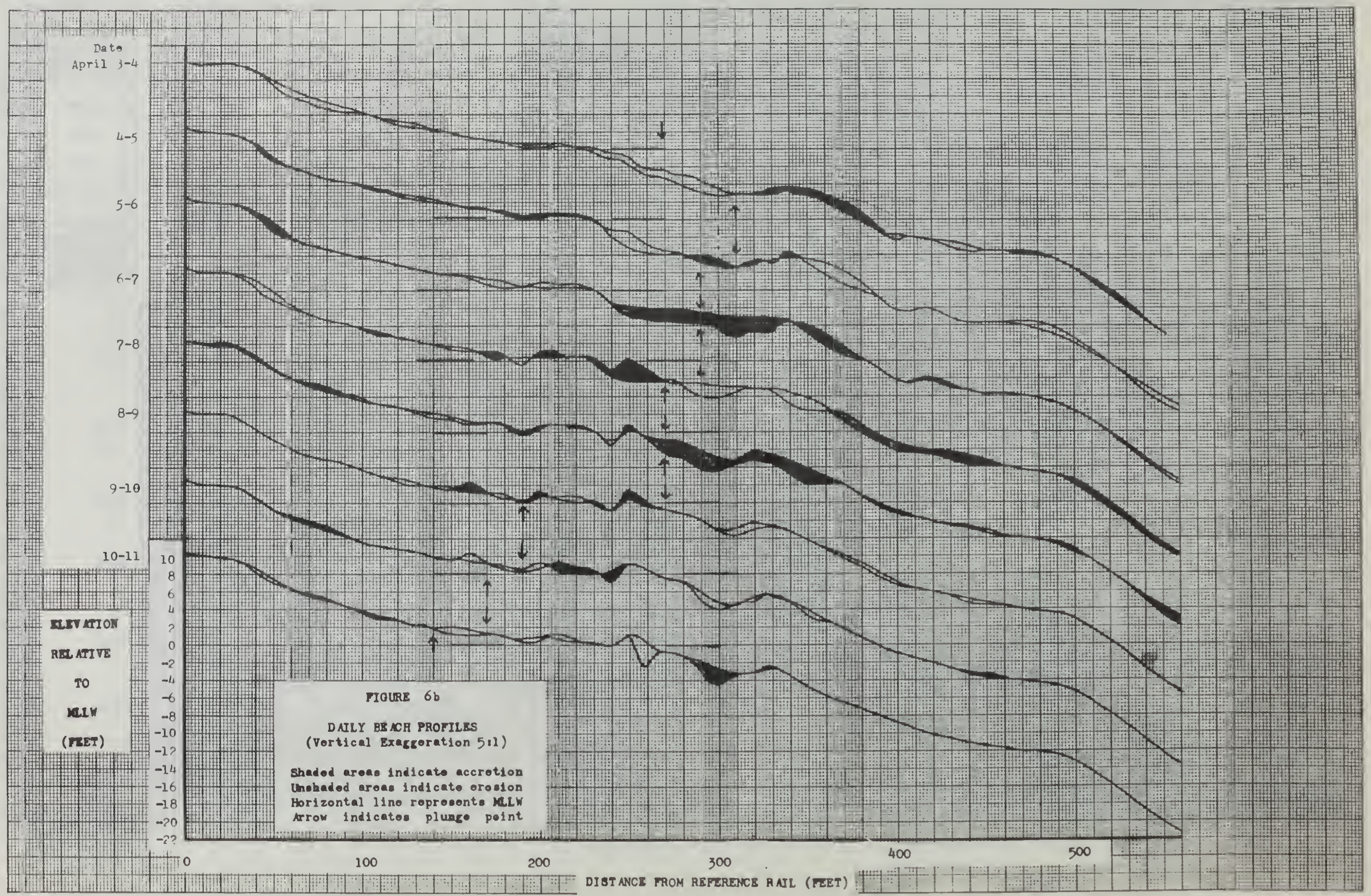


FIGURE 6b

DAILY BEACH PROFILES
(Vertical Exaggeration 5:1)

Shaded areas indicate accretion
Unshaded areas indicate erosion
Horizontal line represents MLLW
Arrow indicates plunge point

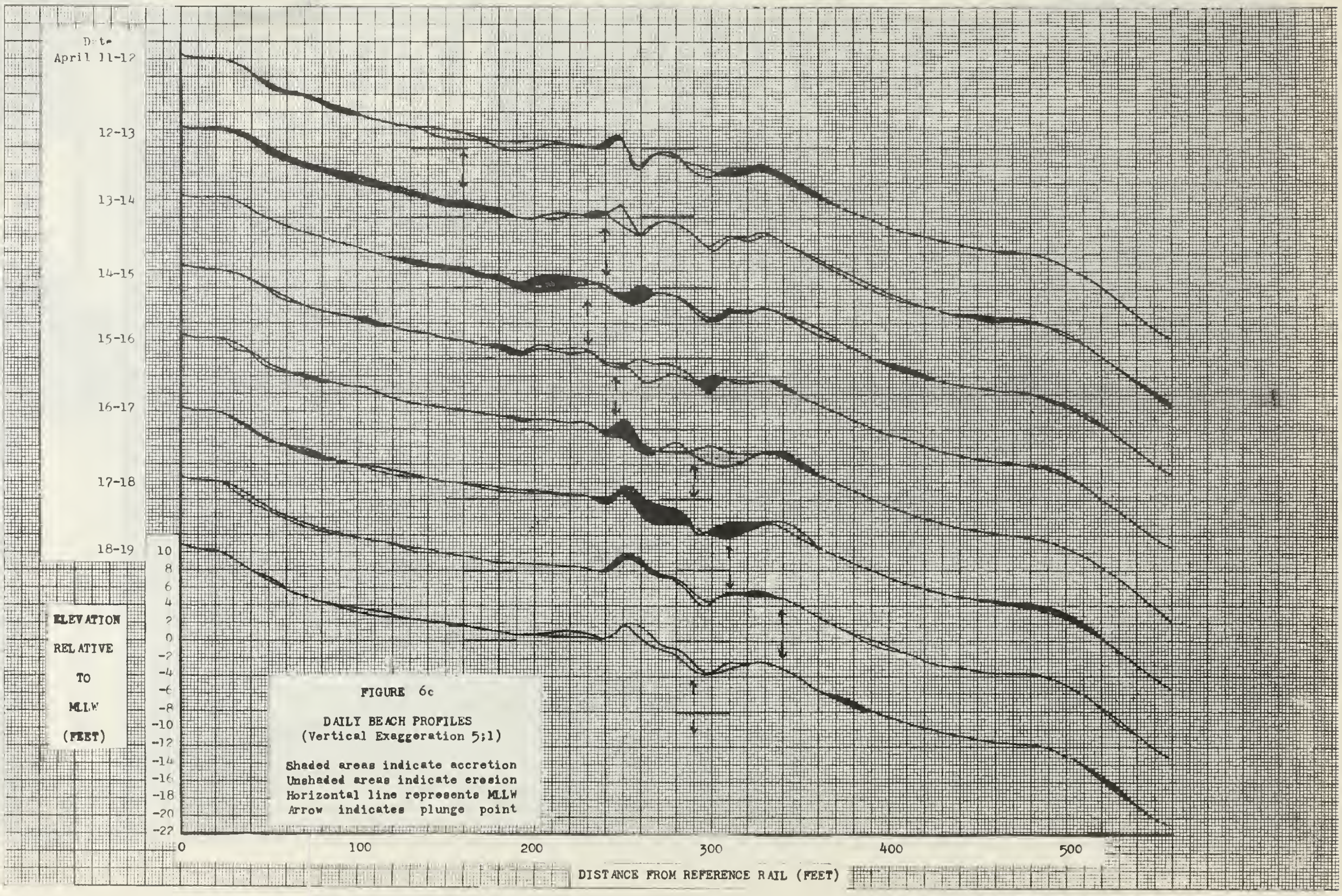


FIGURE 6c

DAILY BEACH PROFILES
(Vertical Exaggeration 5;1)

Shaded areas indicate accretion
Unshaded areas indicate erosion
Horizontal line represents MLLW
Arrow indicates plunge point

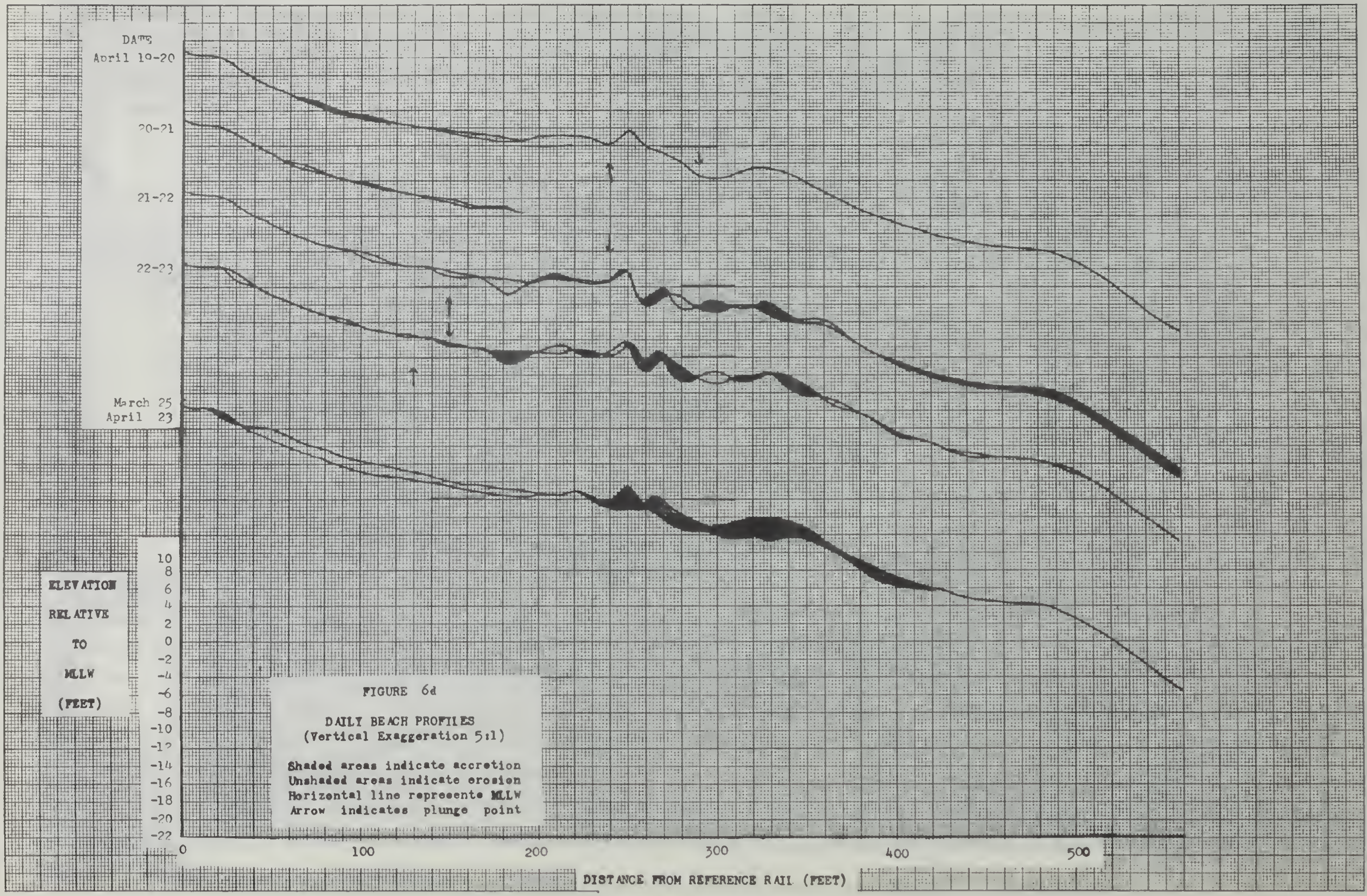


FIGURE 6d

DAILY BEACH PROFILES
(Vertical Exaggeration 5:1)

Shaded areas indicate accretion
Unshaded areas indicate erosion
Horizontal line represents MLLW
Arrow indicates plunge point

(2) Mean Diameter, $M\phi$:

$$M\phi = \tfrac{1}{2}(\phi_{84} + \phi_{16})$$

(3) Standard Deviation, :

$$\sigma\phi = \tfrac{1}{2}(\phi_{84} - \phi_{16})$$

The standard deviation is a measure of the sorting of the sand. If the sorting is perfect, then $\sigma\phi = 0.0$. Good sorting for beach sand is indicated by values of $\sigma\phi \leq 0.5$ (Shore Protection, Planning and Design, 1966).

(4) Skewness, $\alpha\phi$:

$$\alpha\phi = \frac{Md\phi - M\phi}{\sigma\phi}$$

The skewness is a measure of the assymetry of the sample about the median. Negative values indicate that a sample is skewed toward coarser sizes and positive values indicate skewness toward finer sizes.

(5) Kurtosis, $\beta\phi$:

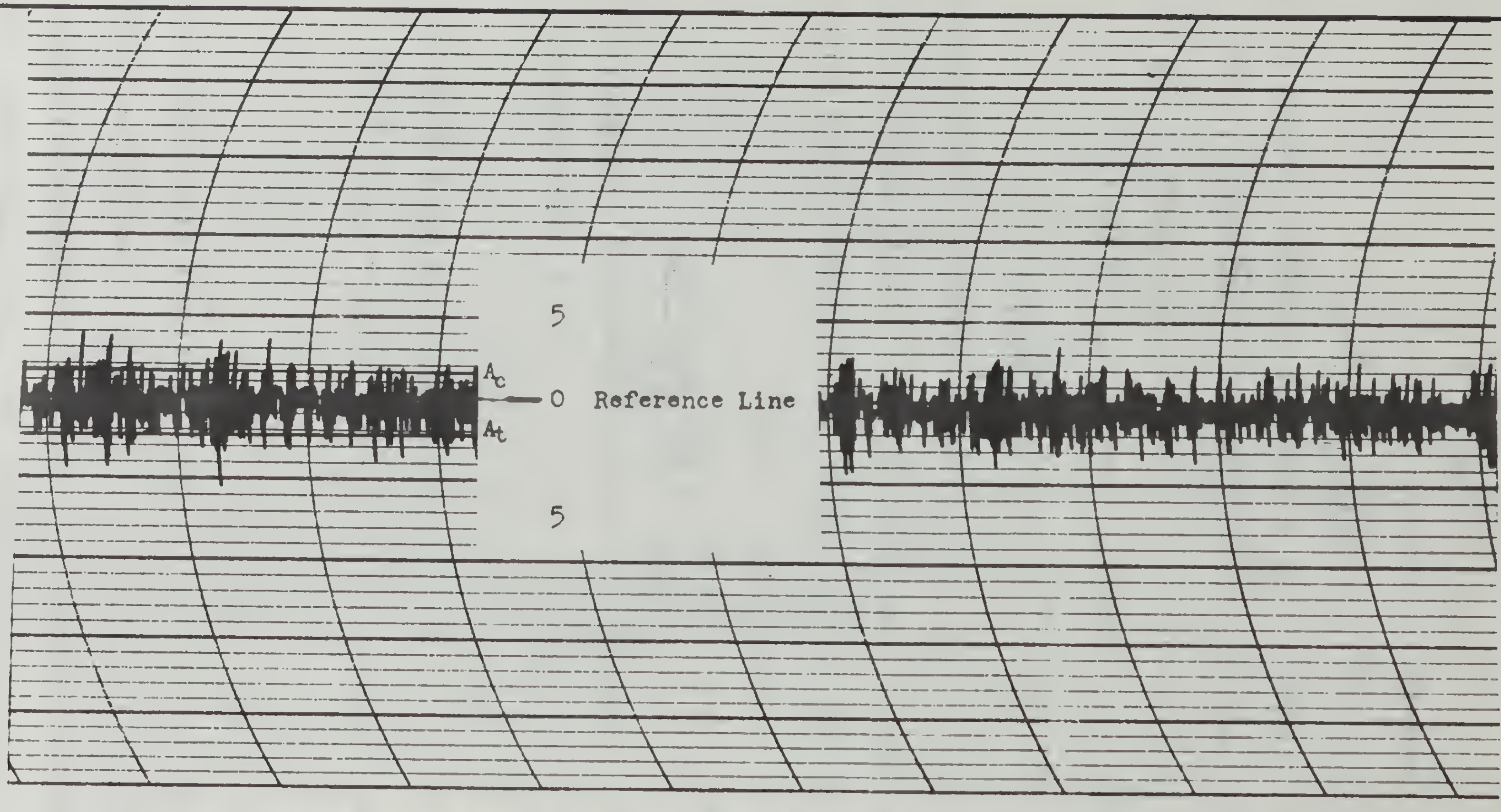
$$\beta\phi = \frac{(\phi_{95} - \phi_5) - \sigma\phi}{2\sigma\phi}$$

Kurtosis is a measure of the peakedness of the grain-size histogram, or the concentration of grain sizes about the mean. For a normal distribution, $\beta\phi = 0.65$.

Values of the median diameter, standard deviation, skewness, and kurtosis are found in Appendices D, E, F, and G.

c. Wave and Tide Data

The wave heights were obtained from the slow trace of the analog recorder by a rapid technique developed by Thompson (1968), which is illustrated in Figure 7. The method involves estimating the crest amplitude, A_c, and the trough amplitude, A_t, such that 1/3 of the crests



A_c - Two-thirds of crest amplitudes are below this value
A_t - Two-thirds of trough amplitudes are below this value
H_{66} - Sum of A_c and A_t

FIGURE 7 WAVE RECORD ANALYSIS

are higher and 1/3 of the troughs are lower than that amplitude. Both amplitudes are estimated beacuse of the asymmetry of waves in shallow water. The sum of A_c and A_t is H_{33}, the wave height such that 1/3 of the waves are larger than this height. This parameter was converted into significant height, $H_{1/3}$, by use of the following relationship from Pierson, Neumann, and James (1955):

$$H_{33} = 2.08 \sqrt{E}$$

$$H_{1/3} = 2.83 \sqrt{E}$$

so that

$$H_{1/3} = 1.36 \, H_{33}$$

This computation gives the significant height of the waves as measured at the underwater sensor. Using the pressure response factor, K (Wiegel, 1964), the values of $H_{1/3}$ at the sensor were converted to $H_{1/3}$ at the surface. No correction was made for the three-foot height of the recorder above the seafloor because the correction is small. In addition, no corrections were made for the depth changes due to the tides although this correction should not be neglected in the case of very short period waves. The values of $H_{1/3}$ at the surface were then converted to H_o', the initial deep water height in the absence of refraction, using the associated wave periods (Wiegel, 1964).

Wave periods were determined from the five-minute fast portion of the trace using well-defined sequences of the dominant waves.

From the above parameters the wave steepness, $\frac{H_o'}{T^2}$, was determined. The above parameters were computed hourly and averaged over a four-hour period (Appendix H).

Tide heights used in this study were read directly from the marigrams and are tabulated in Appendix A and Appendix I. The datum to which all elevations are referred in this study is MLLW.

5. Analysis of Data

a. General Remarks

Examination of the field data revealed a pattern of coarse and fine sand along the profile. The pattern was not stationary, but shifted along the profile from day-to-day. On a daily basis when the location of the coarest sand on the profile was plotted against the observed location of the outermost breakers, a definite relationship was found to exist. It was found that zones of coarse and fine sand followed the position of the plunge point as it migrated back and forth across the beach. Figure 5 shows that the position of the plunge point was determined primarily by the state of the tide on Del Monte Beach and that day-to-day changes in wave height were not sufficient to produce the large changes in the observed plunge-point location.

With regard to the daily changes in sand level observed in the profile, it is evident that the actual movement of sand on a beach is determined, in a complex way, by the wave intensity and the amount of tide change

on the beach. The tides ordinarily cause two transits of the plunge point across the beach each day. Changes in the profile (shown in Figures 6a-d) measured at twenty-four hour intervals therefore represent the net changes brought about by the twice-daily transit of the breaker zone across the beach due to the changing tide. Accordingly, this investigator believes that there is little probability of finding meaningful relationships between these profile changes and the changing wave conditions, or between profile changes and the changing location of the plunge point. Therefore, an attempt to relate profile changes to changing wave conditions generally was abandoned, and possible relationships between sand properties and wave and beach characteristics were investigated.

b. Profile Features

The profile can be divided into three zones: the intertidal portion of the beach, the surf zone, and the offshore zone (Figure 2). The intertidal zone, approximately 190 feet in width, has a fairly constant slope of 1:20 and terminates in a beach flat at the approximate elevation of MLLW. The surf zone, which actually overlaps the intertidal zone, is considered here to extend from 190 to 310 feet from the reference rail. The mean slope in this zone is almost level, but many small irregularities occur and the zone is an area of large and numerous profile changes. The offshore zone

extends from 310 feet to the seaward end of the profile. This zone has both steep and flat slopes and undergoes little change in sand elevation. The terrace at 440 to 490 feet from the reference rail, which ends at a steeper slope to seaward, may represent a beach profile produced by storm waves at an earlier date.

Figure 14 shows the location of well-defined bars and depressions on the profile and the plunge point during the study. Nearly permanent depressions existed at locations 310 feet and 190 feet from the reference rail. These depressions were in general about twenty feet wide. Numerous other depressions existed between the two semipermanent depressions. All the depressions probably are scour depressions created by waves. Two distinct bars usually existed on the profile. One was located about 340 feet from the reference rail and the other 250 feet from the reference rail (Figures 6 and 8). The bar farthest offshore was, in general, 30 to 50 feet in width and the inshore bar was about 20 feet wide. In the mean, the bar locations were permanent although the offshore bar moved inshore about 10 feet on 7 April. The location of the highest point of the bars fluctuated slightly during the study, but the changes were not directly related to wave parameters.

c. Relationships Between Sand Properties and the Plunge Point

(1) Median Diameter

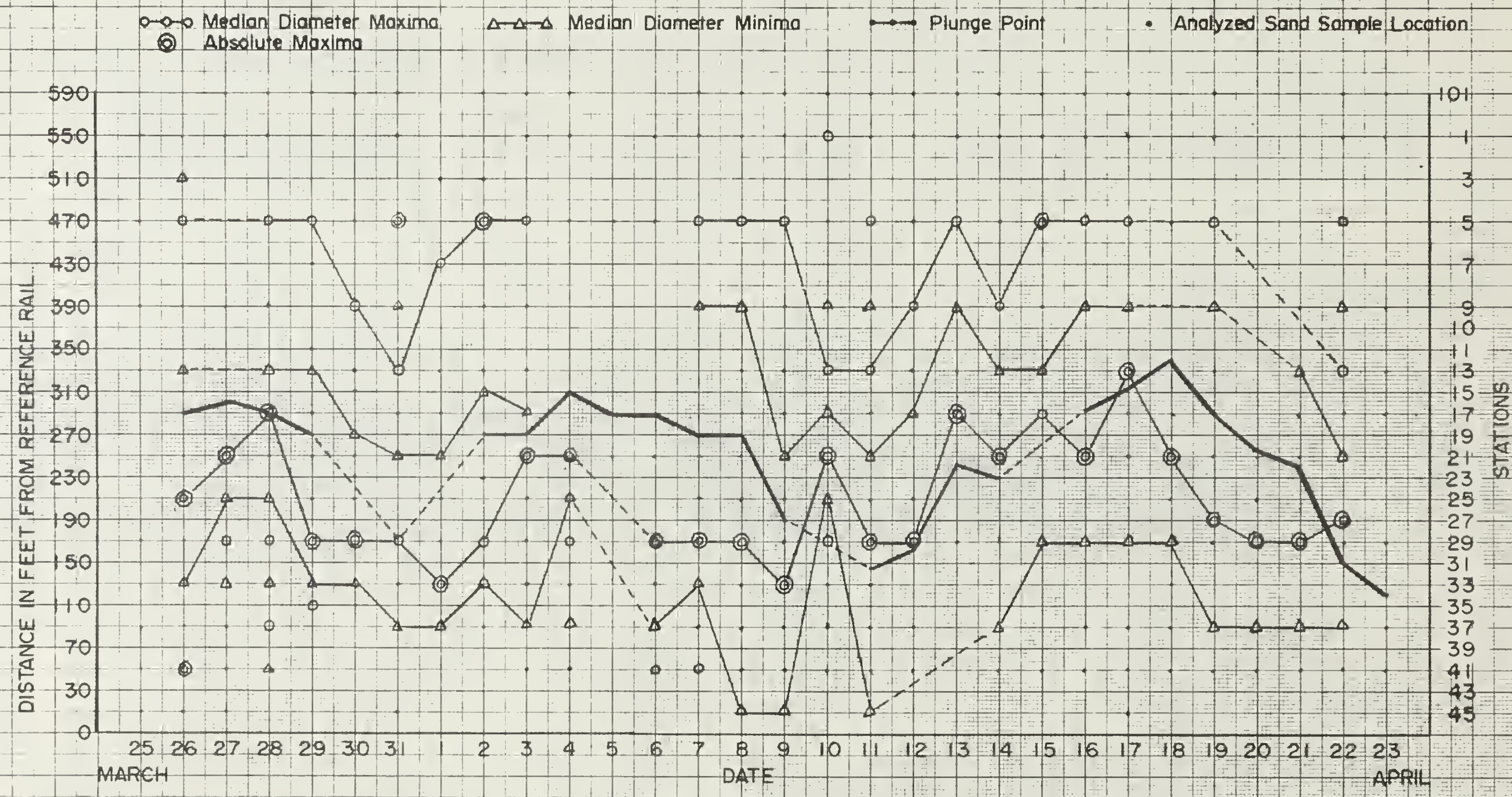


FIGURE 8 Median Diameter Maxima & Minima With Time

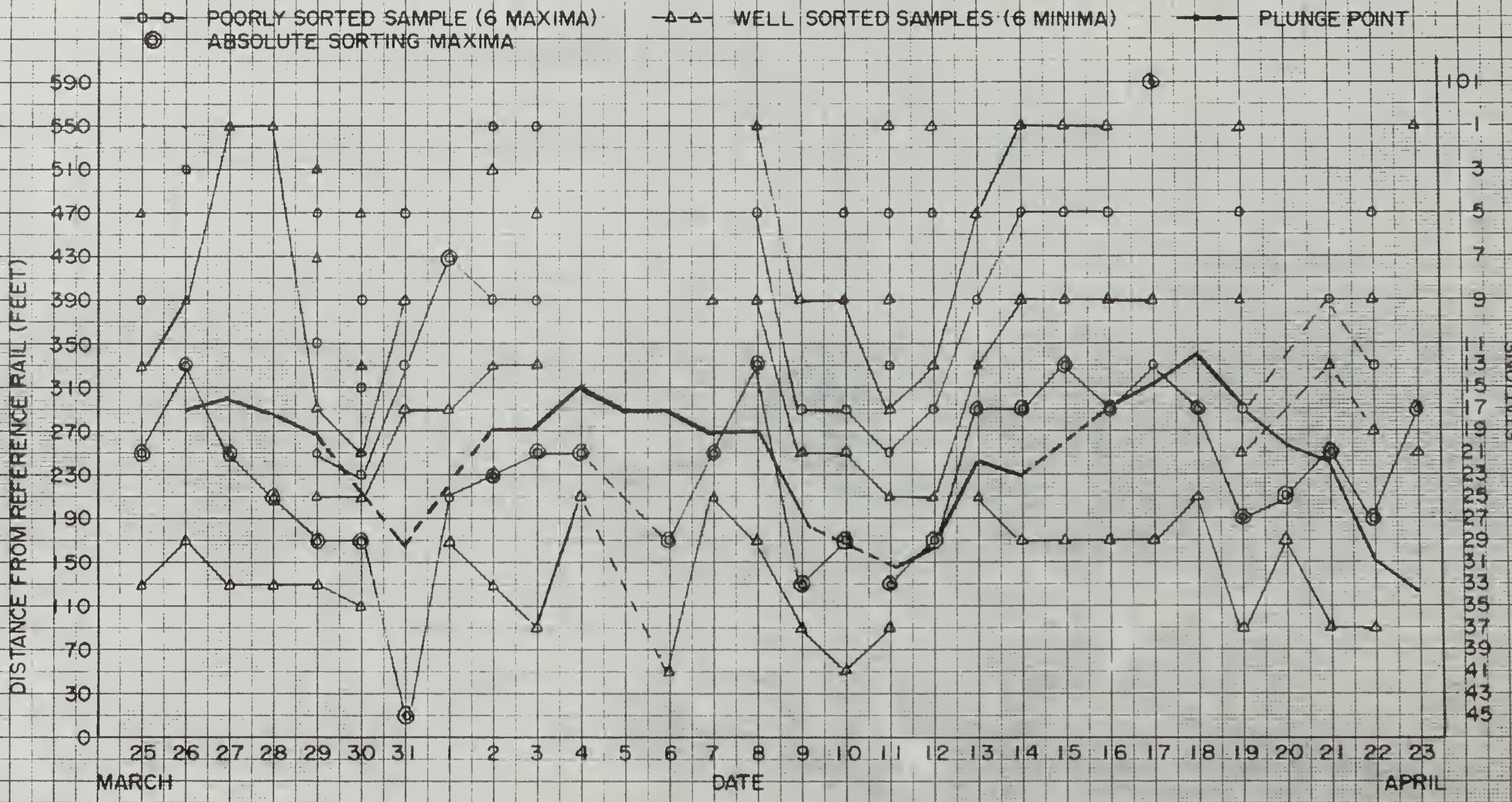


FIGURE 9 SORTING MAXIMA & MINIMA (WITH TIME)

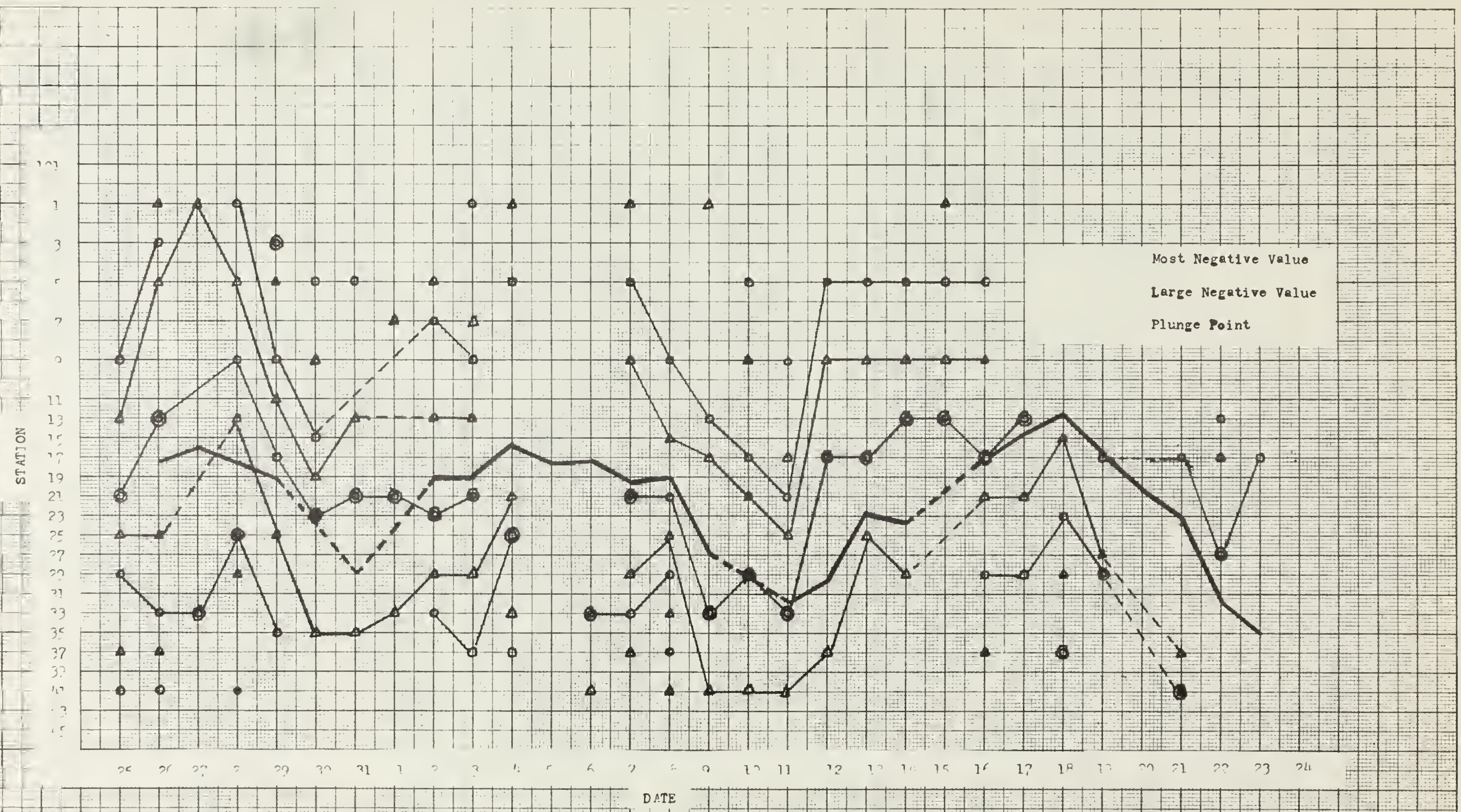


FIGURE 10 SKEWNESS MAXIMA AND MINIMA

Zones of coarse and fine sand closely followed the movement of the plunge point throughout the survey (Figure 8). A zone of coarse sand was found at or just inshore of the plunge point on 18 of 26 days. This zone contained the coarsest sand on the profile for any given day on all but three days, and hereafter referred to as the coarsest zone. On those three days the coarsest sand was found in the most seaward zone of coarse sand (near Station 5). These were days when the wave height was below 0.65 feet, and it is suggested that the wave height may not have been large enough to effectively move or sort the sand.

When the values of the median diameter at each station were averaged for the thirty-day period, it was found that the coarsest sand on the profile occurred at the station closest to the average position of the plunge point (Figure 11). The general range of grain diameter and other sand parameters along the profile also may be seen in the figure. Note that the sand became distinctly finer seaward of Station 5.

A zone of fine sand existed on both sides of the zone of coarsest sand. These two zones, as do the other zones of minima and maxima, also followed the plunge point position.

(2) Sorting

A pattern of relative maxima and minima also existed in the distribution of the standard deviation

values. A zone of poor sorting (large phi deviation) was located near the plunge point (Figure 9) and followed its movement. This zone was the location of the most poorly-sorted samples on 26 of 28 days, and was found shoreward of the plunge point on 16 of 24 days. An adjacent zone of better sorting was found seaward of the plunge point on 20 of 25 days, and another adjacent zone of better sorting was found shoreward of the plunge point on 27 of 27 days. Other zones of maxima and minima also followed the movement of the plunge point. Averages of the deviation values at each station during the study shows that the zone of poor sorting was also near the average location of the plunge point (Figure 11).

(3) Skewness

Skewness values also revealed a pattern that followed the movement of the plunge point (Figure 10). A zone of negatively-skewed sand is located near the position of the plunge point. On 19 of 24 days this zone contained the most negative values found on the profile. Average values of skewness are plotted in Figure 11.

(4) Kurtosis

A pattern of maxima and minima of kurtosis values also existed on the profile, but the pattern shows no apparent relationship to the plunge point. Average values of kurtosis are plotted in Figure 11. Kurtosis values were also tested for relationships with the median diameter, standard deviation, skewness, and

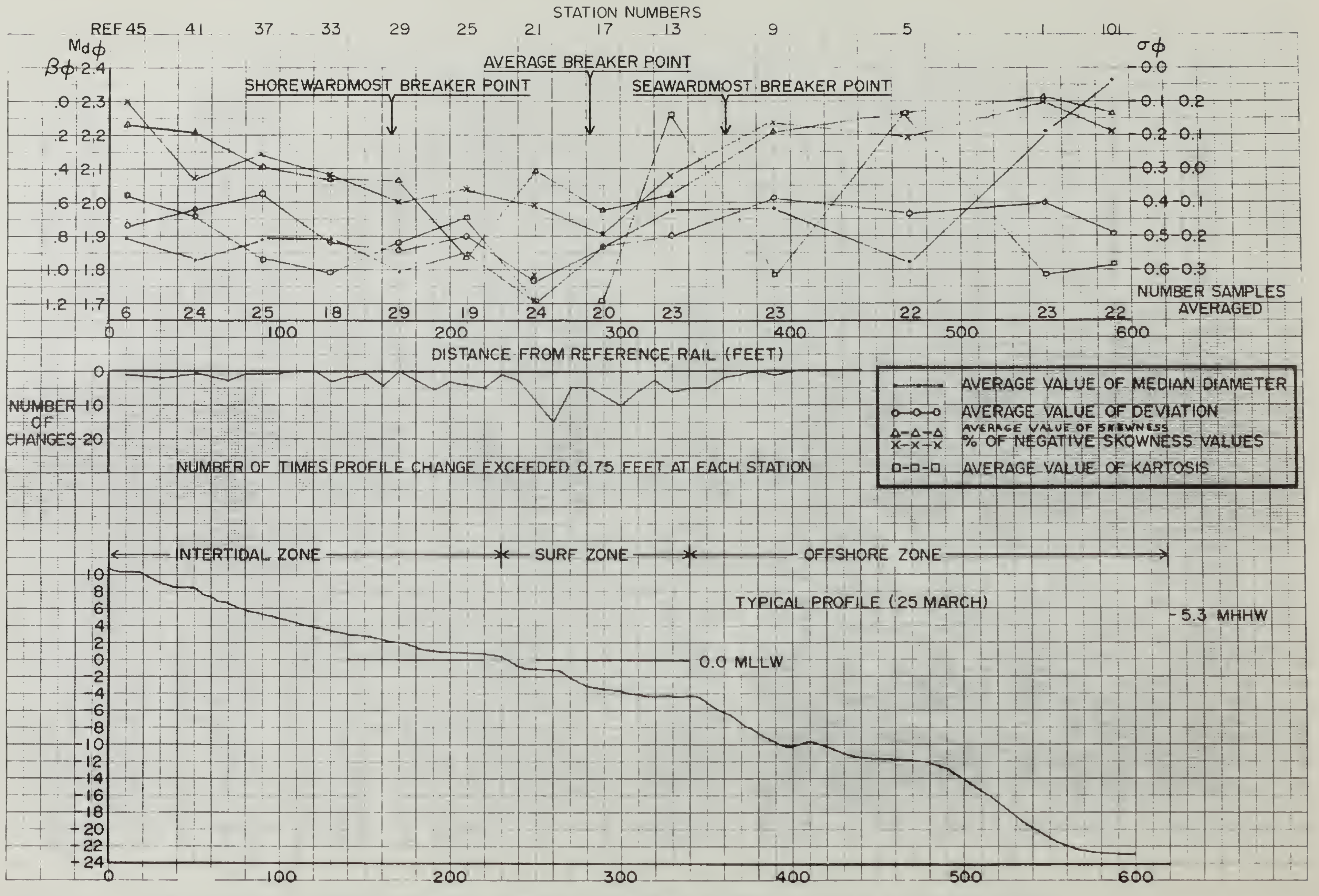


FIGURE 11 Relationship Of Median Diameter, Deviation, Skewness & Beach Activity To Plunge Point

wave steepness; but none were found.

d. Interrelationships Between Textural Parameters

Figure 11 shows that when average values of median diameter and deviation are compared, the poorest-sorted zone coincides with the zone of coarsest sand, and also that the adjacent zones of better sorting coincide with zones of finer sand. Comparison of Figures 8 and 9 reveals that stations with coarsest sand and poorest sorting coincided on 11 of 28 days.

It was also found that a relationship exists between the degree of coarseness and degree of sorting over the entire profile. Values of the median diameter and deviation are plotted in Figure 12 for the special case of those samples taken from the coarsest zone, and these values reveal the same relationship.

A definite interrelationship also exists between the skewness of a sample and the coarseness and sorting of the sample. Of the 319 samples analyzed 38% were skewed negatively; however, samples from the coarse-grained stations near the plunge point were skewed negatively in 81% of the cases, and samples from the poorly-sorted zone near the plunge point were skewed negatively in 71% of the cases. In addition, on 15 of 28 days the station with poorest sorting coincided with the station of maximum negative skewness.

e. Relationship of Sand Parameters to Daily Profile Changes

Examination of the profile in connection with the sand properties shows that the areas of coarsest and most poorly sorted sand tended to be found where the profile filled during the previous 24 hours (Table 3).

f. Relationship Between Median Diameter, Sorting, and Wave Steepness

Not only did the sorting of samples become poorer with increasing coarseness, but this relationship was affected by the wave steepness at the time of the observations (Figure 12). As the wave steepness decreased, the sand samples became coarser and more poorly sorted, and the converse is also true. This indicates that long, low waves are less efficient sorters of sand than short, choppy waves.

g. Relationship Between Median Diameter and Profile Slope

Table 4 presents values of the average slope and the average median diameter at the sampling stations. Slope values were determined by estimating an average value from the profiles of 25 March and 23 April. No relationship between median diameter and slope was found on any part of the profile. The intertidal zone had a wide range of slopes with a nearly constant median diameter. The surf zone had, in general, a level profile with many small undulations and a wide range of median diameter values. In the offshore zone, the median diameter did not show a relationship to slope but decreased with distance seaward from Station 5.

TABLE 3

Profile Slope vs. Median Diameter

Station	Average Slope ($\Delta y/\Delta x$)	Average Median Diameter (ϕ units)
1	0.20	2.196
5	0.10	1.82
9	0.165	1.98
13	0.02	1.97
17	0.06	1.86
21	0.02	1.70
25	0.0001	1.84
29	0.025	1.79
33	0.025	1.89
37	0.06	1.89
41	0.065	1.86
45	0.020	1.87

TABLE 4

Relationship Between Sand Properties
and Profile Cut and Fill

Parameters	Cut	No Change	Fill
	Number of Days of Cut and Fill		
Largest Median Diameter*	6	9	12
Largest Deviation Value*	9	8	12
Largest Negative Skewness*	11	2	8
Largest Kurtosis Value	6	7	12

* The figures refer to the coarsest sample, the most poorly sorted sample, and the most negatively skewed sample collected near the plunge point each day.

h. Profile Shape and Profile Changes in Relation to Various Factors

(1) Relationship Between Profile Activity and Tide Changes

Figure 13 shows the number of stations on the profile which had a 0.25-foot change in sand elevation during the twenty-four hour sampling interval. It also shows a plot of the number of hours to the nearest tide change. Near the time of a tide change little activity occurs, while more activity takes place at mid-tide levels. Since evidence in the form of changing sand properties indicates that changes in the profile occur during each tide rise or fall, then the change based on a twenty-four sampling interval would not necessarily be expected to show the above relationship. This relationship can be explained satisfactorily only if the beach assumes nearly the same profile at each high and low tide level when water-level changes are small, but has a rapidly changing profile at mid-tide levels when water level changes are comparatively large. Large changes in wave conditions can alter the above relationship. On 16-17 April, when a large number of changes occurred along the profile, the wave height was higher than normal and may have sifnificantly altered the profile so that on 17 April it did not assume the high tide shape of the day before.

No other relationship was found (or was expected to be found for the reasons stated in paragraph 5a) connecting the changes in the beach profile and changes

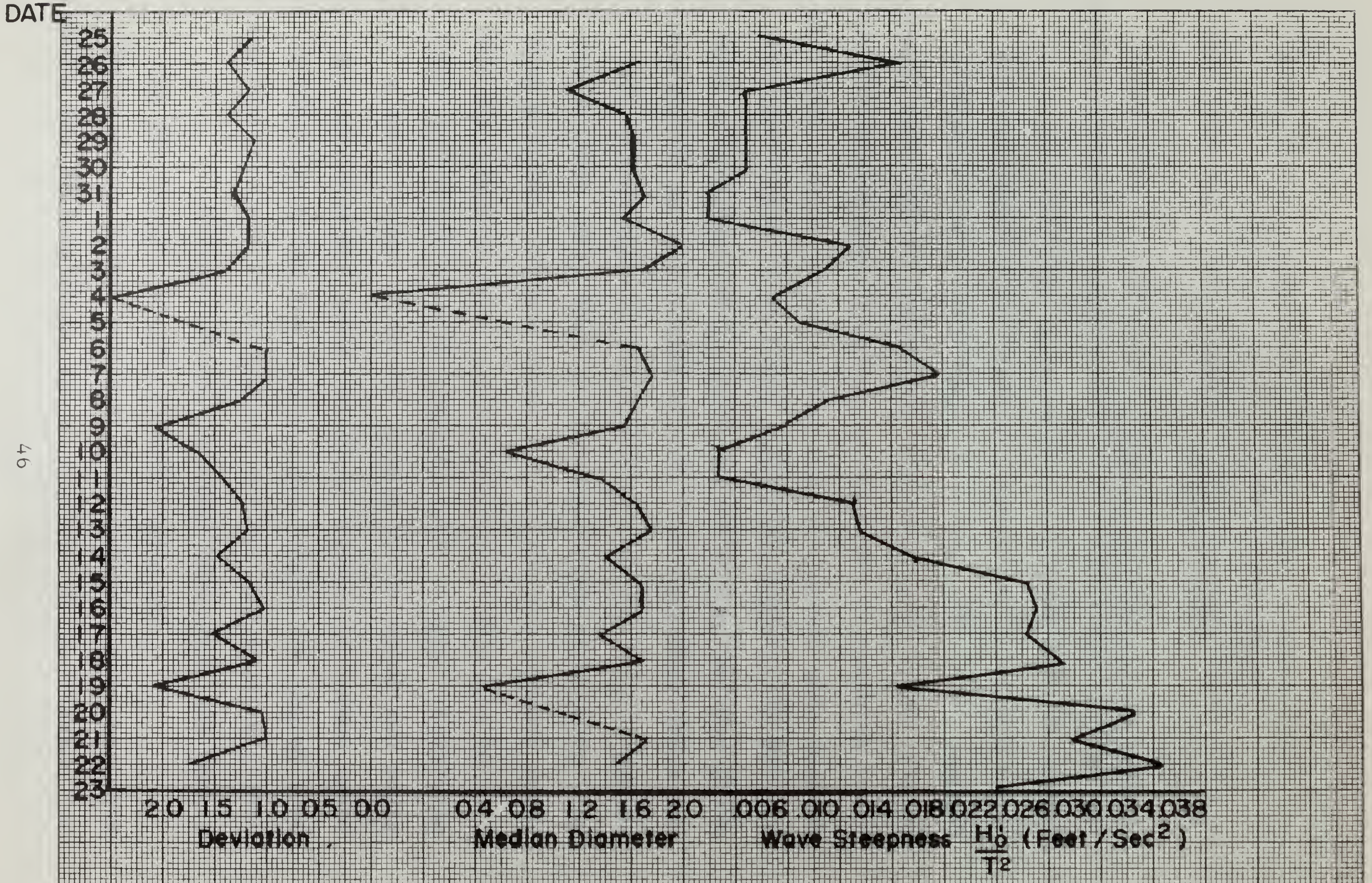


FIGURE 12 Median Diameter & Deviation At Station With Coarsest Sand Vs. Wave Steepness

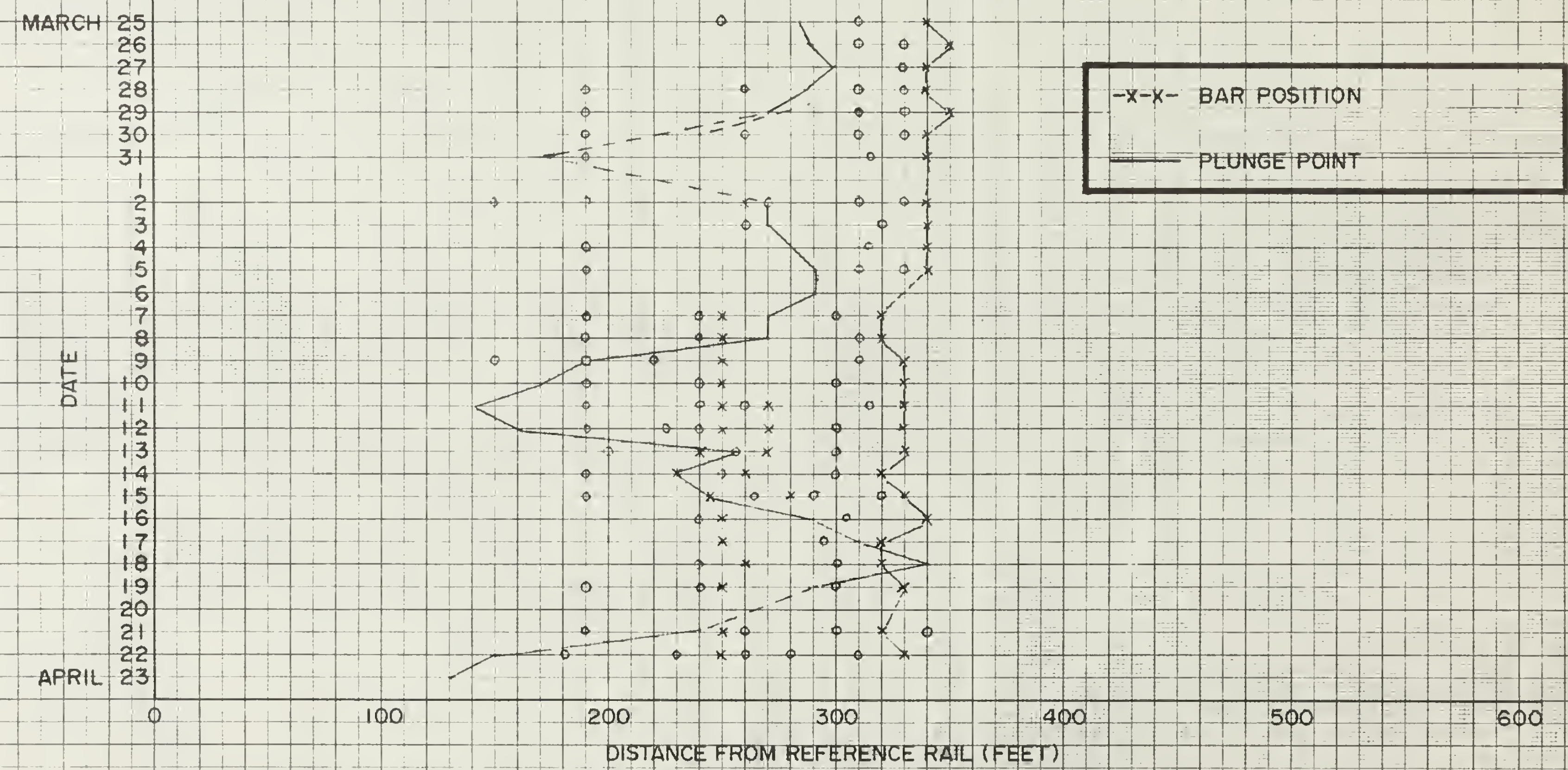


FIGURE 13 BAR & DEPRESSION LOCATIONS WITH TIME

in wave properties, other than that the area under the breaker zone experienced the most activity (Figure 11).

(2) Relationship of Depressions on the Profile to Wave Action

The two semipermanent troughs located at 190 and 310 feet from the reference rail may have been the result of wave activity at the high and low tide levels (Figure 14). The plunge point remains at a given location for the longest period at high and low tide stages because the turning of the tide maintains the water level constant for a considerable period of time. Wave action therefore may act at this point long enough to create a depression which, although cut and filled to some extent by wave action at other tide levels, remains as a semipermanent feature of the profile. The other depressions were temporary in nature, possibly having been formed by a transient wave position passing over that location. Some of the depressions also could have been temporary rip channels running across the profile, although sand samples taken at these locations were not coarser than normal as is sometimes the situation in rip channels (Ingle, 1966).

(3) Relationship between Bars and Profile Cut and Fill

On most days when the highest point on the bars changed location, it is possible to relate the changes in location to local cut and fill on the profile during the preceding twenty-four hours (see 16-17 April, Figure 6c).

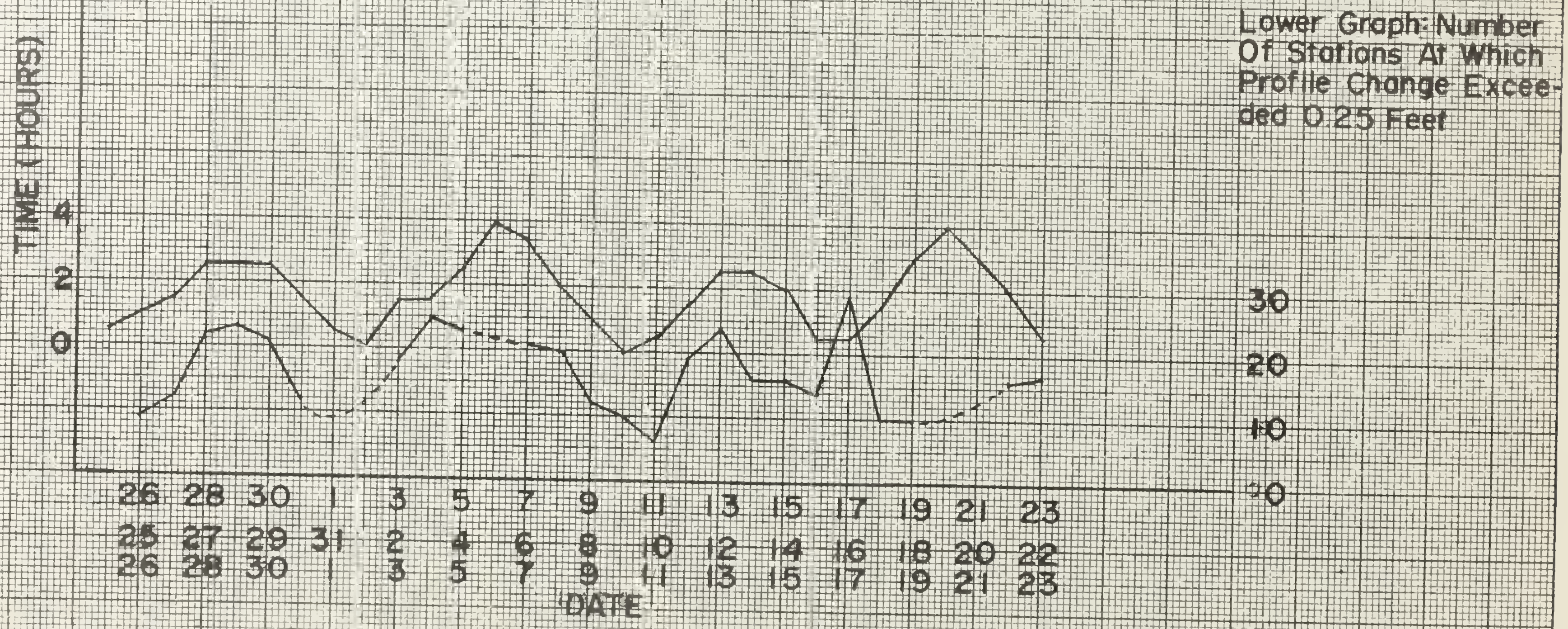


FIGURE 14 Relationship Between Time To Nearest High Or Low Tide & Profile Activity

i. Summary of Principal Findings

(1) Alternating zones of maxima and minima of each sand property (median diameter, standard deviation, skewness, and kurtosis) were found to lie parallel to the shoreline.

(2) These zones moved onshore and offshore with the changing tide.

(3) The zones of coarsest, most poorly sorted, and most negatively skewed sand were found at or near the plunge point.

(4) The zones of most poorly sorted sand and most negatively skewed sand usually coincided with the zone of coarsest sand, and zones of better sorted and positively skewed sand were related to finer grained sand zones.

(5) The sand on the profile became coarser and more poorly sorted as the wave steepness decreased, and finer and better sorted as wave steepness increased.

(6) The number of stations exhibiting changes on the profile during a twenty-four hour period is evidently a function of the tide stage. Few profile changes occurred near high or low tides, while changes were numerous during mid-tide stages.

6. Conclusions

Sand on Del Monte Beach displays definite patterns in the distribution of its textural properties. Zones of maxima and minima of median diameter, standard deviation,

skewness, and kurtosis are found parallel to the shoreline. The zones coincide to produce zones of coarse, poorly sorted, negatively skewed sand and zones of finer, better sorted, positively skewed sand. The steepness of the waves incident on the beach apparently determine the magnitude of the textural parameters--the steeper the waves the finer and better sorted is the sand. The patterns of sand properties move on and off the beach under the influence of the tides.

There are two ways in which the observed zones of coarse sand could have been formed. One is by the removal of the small grains from the zone and the other is by the addition of large grains. Both can produce zones of coarse sand with predominantly negative skewness values. However, the fact that the sorting of a sample became poorer as the sample became coarser means that large grains must be transported with the moving plunge point and that fine grains must remain in essentially the same location. Transport of large grains to a zone near the plunge point also produces the adjacent zones of finer, better sorted sand. These field observations are similar to the laboratory results obtained by Ippen and Eagleson (1955).

The change in tide level, which causes the migration of the sand properties across the beach, also influences the shape of the profile. It appears that the beach has one profile which is formed at each high tide and another profile which is formed at each low tide. The amount of

change which occurs on the profile is related to the tide stage. The greatest change on the profile occurs at mid-tide levels and the smallest occurs at high and low tide.

This investigator believes that if a sampling interval of a few hours were used instead of the 24-hour interval used in this study, it would be possible to relate profile changes to varying wave and tide conditions, and also to differentiate between the effects of waves and tides in altering the profile and sand property patterns.

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APPENDIX A

Tide, Wave Height, Plunge Point, Beach Cusp and Wind Data at the Time of Observations

Date	Obs. Time	Tide Height[1] (feet)	Tide Stage	Wave Height Ho' (feet)
MARCH				
25	1500	-0.7	Rising	0.59
26	1500	-0.4	Low	1.72
27	1500	0.1	Falling	0.90
28	1500	0.8	Falling	0.89
29	1500	1.6	Falling	0.87
30	1500	2.2	Falling	0.52
31	1500	3.3	Falling	0.21
APRIL				
1	0900	1.6	Rising	0.29
2	0900	0.9	Rising	0.62
3	0900	0.4	Falling	1.25
4	0900	0.3	Falling	Low
5	0900	0.7	Falling	1.58
6	0900	1.1	Falling	1.99
7	0900	1.8	Falling	1.80
8	0900	3.0	Falling	1.08
9	0900	4.0	Falling	0.66
10	0900	4.5	Falling	0.44
11	0900	4.9	Falling	
12	0900	4.7	Rising	1.86
13	0900	3.6	Rising	1.73
14	0900	1.0	Rising	1.34
15	0900	1.0	Rising	1.69
16	0900	-0.3	Rising	2.48
17	0900	-1.0	Rising	1.96
18	0900	-0.9	Falling	1.59
19	0900	-0.2	Falling	0.96
20	0900	1.0	Falling	2.21
21	0900	2.9	Falling	1.69
22	0900	3.5	Falling	0.52
23	0900	3.5	Falling	

1. Relative to MLLW

Date	Plunge Point[2]	Cusps Present	Wind (Kn) Speed
MARCH			
25	285		
26	290	Yes	5-8
27	300	Yes	5-8
28	290	Yes	8-10
29	270	Yes	8-10
30	240	Yes	5-10
31	170	Yes	8-10
APRIL			
1			
2	270	No	15-22
3	270	Yes	0
4	310	No	0
5	290	Yes	0
6	290	Yes	0
7	270	Yes	0
8	270	Yes	0
9	190	Yes	0
10	170	Yes	0
11	140	Yes	0
12	160	Yes	0
13	240	Yes	0
14	230	No	
15	245	No	5-10
16	290	No	15
17	310	No	0
18	340	No	0
19	290	No	0
20		No	0
21	240	No	0
22	150	No	0
23	130	No	0

2. Distance from Reference Rail

APPENDIX B

Daily Sand Elevations Relative to Mean Lower Low Water

(in feet)

STATION DAY	1	2	3	4	5
MARCH					
25	-21.19	-18.53	-15.53	-12.92	-11.79
26	-21.19	-18.53	-15.42	-12.96	-11.83
27	-21.20	-18.59	-15.36	-13.02	-11.84
28	-21.22	-18.49	-15.42	-13.03	-11.79
29	-21.27	-18.73	-15.50	-13.09	-11.91
30	-21.18	-18.65	-15.47	-13.03	-11.83
31	-21.08	-18.49	-15.20	-13.05	-11.82
APRIL					
2	-21.21	-18.68	-15.43	-13.02	-11.82
3	-21.12	-18.60	-15.54	-13.12	-11.99
4	-21.13	-18.86	-15.93	-13.12	-11.61
5	-21.23	-19.01	-15.70	-13.38	-12.12
6	-21.23	-19.01	-15.70	-13.38	-12.12
7	-21.23	-18.72	-15.54	-13.09	-12.17
8	-21.17	-18.69	-15.44	-13.08	-12.13
9	-21.23	-18.59	-15.41	-13.02	-12.09
10	-21.24	-18.61	-15.48	-13.09	-11.95
11	-21.25	-18.60	-15.50	-13.10	-12.00
12	-21.23	-18.56	-15.48	-13.12	-11.83
13	-21.12	-18.55	-15.54	-13.12	-11.97
14	-21.14	-18.66	-15.48	-13.02	-11.90
15	-21.18	-18.60	-15.49	-13.16	-12.03
16	-21.21	-18.64	-15.50	-13.10	-12.03
17	-21.05	-18.59	-15.38	-12.83	-11.83
18	-21.19	-18.59	-15.35	-13.07	-11.84
19	-21.08	-18.58	-15.39	-13.06	-11.73
20	-21.08	-18.58	-15.39	-13.06	-11.73
21	-21.08	-18.58	-15.39	-13.06	-11.73
22	-21.08	-18.40	-15.50	-13.04	-11.83
23	-21.09	-18.56	-15.38	-13.12	-11.92

STATION DAY	6	7	8	9	10
MARCH					
25	-11.54	-11.18	- 9.82	- 9.99	-7.41
26	-11.53	-11.18	- 9.87	-10.07	-7.74
27	-11.65	-11.34	- 9.90	-10.03	-6.98
28	-11.61	-11.35	- 9.89	-10.17	-7.49
29	-11.52	-10.93	-10.36	-10.01	-7.56
30	-11.59	-11.35	- 9.82	-10.15	-7.49
31	-11.41	-11.09	- 9.87	-10.08	-7.39
APRIL					
2	-11.55	-11.37	- 9.87	-10.17	-7.62
3	-11.68	-10.92	-10.40	- 9.96	-7.70
4	-11.56	-11.54	-10.23	-10.47	-7.76
5	-11.91	-11.47	-10.05	-10.27	-7.63
6	-11.91	-11.47	-10.05	-10.27	-7.63
7	-11.75	-10.65	-10.06	- 9.13	-7.11
8	-11.76	-11.03	-10.16	- 8.93	-7.04
9	-11.72	-10.95	- 9.95	- 8.92	-7.10
10	-11.69	-10.95	-10.03	- 8.89	-7.17
11	-11.60	-11.00	-10.00	- 8.80	-7.20
12	-11.64	-11.09	-10.02	- 8.83	-6.94
13	-11.66	-11.02	-10.06	- 8.84	-6.93
14	-11.47	-11.05	- 9.93	- 8.69	-6.97
15	-11.73	-11.05	-10.13	- 8.87	-7.06
16	-11.65	-11.09	-10.16	- 8.83	-6.97
17	-11.50	-11.09	-10.14	- 8.84	-6.98
18	-11.36	-11.03	-10.02	- 8.93	-7.16
19	-11.39	-11.04	-10.05	- 8.84	-7.04
20	-11.39	-11.04	-10.05	- 8.84	-7.04
21	-11.39	-11.04	-10.05	- 8.84	-7.04
22	-11.50	-11.05	- 9.93	- 8.76	-6.77
23	-11.58	-11.12	- 9.97	- 8.84	-6.66

STATION DAY	11	12	13	14	15
MARCH					
25	-5.17	-4.12	-4.78	-4.29	-4.63
26	-5.29	-4.62	-4.78	-4.20	-4.55
27	-5.31	-4.32	-5.02	-4.70	-4.50
28	-5.25	-4.34	-4.70	-4.29	-4.63
29	-5.72	-4.63	-4.96	-4.70	-5.30
30	-5.56	-4.55	-5.20	-4.63	-4.96
31	-5.69	-4.67	-4.40	-4.68	-5.10
APRIL					
2	-5.94	-4.90	-5.47	-4.93	-5.16
3	-5.75	-5.04	-5.42	-5.29	-5.33
4	-4.90	-4.40	-4.70	-5.00	-5.40
5	-6.08	-3.53	-5.05	-4.77	-5.49
6	-6.08	-3.53	-5.05	-4.77	-5.49
7	-5.80	-4.50	-3.41	-3.13	-3.97
8	-5.00	-3.25	-2.70	-2.45	-3.56
9	-5.40	-3.40	-2.62	-3.10	-3.69
10	-5.42	-3.43	-2.59	-3.26	-3.62
11	-5.42	-3.33	-2.67	-3.33	-3.26
12	-5.06	-2.77	-1.93	-2.41	-2.45
13	-4.89	-3.03	-2.46	-3.00	-2.90
14	-5.26	-3.21	-2.51	-3.03	-2.64
15	-5.35	-2.96	-2.59	-3.10	-2.83
16	-5.26	-2.41	-2.75	-3.60	-4.40
17	-5.32	-3.01	-2.75	-2.82	-2.90
18	-5.51	-3.23	-2.50	-2.77	-2.67
19	-5.51	-3.41	-2.57	-2.67	-3.40
20	-5.51	-3.41	-2.57	-2.67	-3.40
21	-3.67	-3.90	-4.00	-2.40	-2.40
22	-4.76	-3.92	-2.00	-2.40	-2.88
23	-4.73	-2.34	-4.00	-2.46	-2.41

STATION DAY	16	17	18	19	20
MARCH					
25	-3.98	-3.49	-3.27	-2.45	-0.91
26	-3.48	-2.50	-2.44	-2.45	-1.99
27	-4.00	-3.30	-2.80	-2.15	-1.20
28	-3.98	-3.70	-3.44	-2.78	-2.79
29	-4.46	-4.03	-3.36	-2.78	-1.00
30	-4.25	-3.57	-3.04	-2.24	-2.39
31	-4.26	-3.55	-3.02	-2.40	-2.31
APRIL					
2	-4.00	-3.44	-2.96	-2.50	-2.70
3	-4.37	-3.45	-3.13	-2.41	-2.54
4	-5.40	-4.90	-4.00	-3.50	-3.00
5	-4.43	-4.00	-3.90	-4.00	-3.70
6	-4.43	-4.00	-3.90	-4.00	-3.70
7	-4.67	-4.18	-2.74	-2.42	-0.77
8	-2.89	-2.30	-1.27	-0.88	-0.63
9	-3.20	-2.00	-1.09	-0.85	0.30
10	-4.77	-2.70	-1.19	-1.05	0.30
11	-4.81	-2.00	-1.20	-1.00	-2.74
12	-4.04	-0.82	-0.83	-0.67	-2.54
13	-4.50	-2.40	-1.03	-0.83	-2.34
14	-4.71	-2.40	-0.96	-0.77	-0.27
15	-2.48	-2.80	-1.80	-2.80	-2.87
16	-4.10	-3.20	-2.80	-2.70	-2.44
17	-4.38	-2.93	-1.06	-0.82	0.40
18	-4.50	-3.64	-0.87	-0.68	1.20
19	-4.71	-3.30	-1.60	-0.83	-0.00
20	-4.71	-3.30	-1.60	-0.83	-0.00
21	-3.68	-2.80	-1.40	-0.31	0.60
22	-2.11	-2.78	-2.61	-0.11	1.13
23	-3.42	-3.15	-1.60	-0.18	-2.08

STATION DAY	21	22	23	24	25
MARCH					
25	-1.13	-1.01	-0.00	0.27	0.56
26	-0.71	-0.60	0.09	0.45	0.51
27	-0.70	-0.69	-0.10	0.07	0.50
28	0.68	-0.14	-0.29	-0.36	-0.04
29	0.0	0.50	0.75	0.74	0.61
30	-0.71	-0.43	0.13	-0.01	0.35
31	-0.68	-1.00	0.04	0.11	0.61
APRIL					
2	-1.80	-1.25	-0.04	0.08	0.31
3	-0.90	-0.68	0.08	0.24	0.40
4	-1.43	-1.14	-0.23	0.0	0.22
5	-3.10	-1.83	0.06	0.37	0.54
6	-3.10	-1.83	0.05	0.16	0.23
7	0.12	-1.52	0.34	0.27	0.69
8	0.43	-1.44	0.0	0.61	0.55
9	1.34	-1.31	0.00	-0.30	0.22
10	1.12	-0.42	0.17	0.54	1.14
11	1.24	-0.50	0.0	0.20	0.50
12	1.51	0.20	-0.20	0.20	0.29
13	-1.60	0.07	0.13	0.0	-0.40
14	-1.00	-0.36	0.86	0.98	1.06
15	-0.90	-0.73	0.56	0.67	0.80
16	1.15	-0.71	0.45	0.62	0.78
17	1.41	-0.35	0.29	0.36	0.41
18	1.71	-0.21	0.40	0.44	0.46
19	1.61	-0.16	0.70	0.79	0.78
20	1.61	-0.16	0.70	0.79	0.78
21	1.71	0.07	0.07	0.48	0.42
22	1.71	0.50	0.0	0.48	1.22
23	1.71	-0.35	0.46	0.87	0.37

STATION DAY	26	27	28	29	30
MARCH					
25	0.77	1.08	0.98	1.37	1.81
26	0.69	1.08	1.05	1.38	1.73
27	0.87	0.80	1.29	1.50	1.72
28	0.15	-0.41	0.41	0.94	1.37
29	0.54	-0.41	0.47	0.96	1.21
30	-0.20	-0.29	0.76	0.88	1.43
31	0.60	0.10	0.75	1.06	1.42
APRIL					
2	0.47	-0.11	0.54	1.50	2.50
3	0.50	0.46	0.86	1.17	1.53
4	0.29	-0.18	0.73	1.09	1.44
5	0.57	0.25	0.81	1.07	1.33
6	0.21	-0.80	0.08	0.54	1.07
7	0.67	-0.60	0.58	0.87	1.17
8	0.54	-0.20	0.66	0.79	0.78
9	1.13	-0.10	0.43	1.20	2.26
10	0.67	0.05	0.68	0.95	1.22
11	0.70	0.35	0.78	1.17	1.42
12	-0.30	-0.47	0.18	0.54	0.84
13	-0.60	-0.31	0.53	0.87	1.52
14	1.12	0.12	0.99	1.40	1.81
15	1.00	0.64	1.28	1.49	1.76
16	1.00	0.97	1.28	1.54	1.72
17	0.58	0.55	0.84	1.08	1.39
18	0.56	0.48	0.74	1.02	1.28
19	0.71	0.40	0.75	0.98	1.26
20	0.71	0.05	0.58	0.67	0.96
21	0.70	0.28	0.61	0.88	1.14
22	0.56	-0.47	-1.29	0.67	0.89
23	0.53	0.22	0.41	0.65	1.04

STATION DAY	31	32	33	34	35
MARCH					
25	2.14	2.72	2.90	3.34	3.82
26	2.04	2.36	2.73	3.29	3.78
27	1.89	2.30	1.98	3.03	3.52
28	1.94	2.37	2.78	3.26	3.81
29	1.69	2.23	2.82	3.41	3.92
30	1.82	2.26	2.78	3.32	4.04
31	1.66	1.71	2.49	3.30	4.22
APRIL					
2	1.62	2.71	2.78	3.08	3.71
3	1.88	2.27	2.70	3.13	3.59
4	1.80	2.18	2 60	2.97	3.41
5	1.69	1.67	2.38	2.77	3.11
6	1.41	1.78	2.13	2.52	2.93
7	1.60	1.95	2.29	2.67	3.12
8	1.35	1.50	1.72	2.37	2.84
9	1.22	1.52	2.13	2.56	2.95
10	1.50	1.74	2.15	2.65	2.86
11	1.60	1.94	2.25	2.55	3.04
12	0.98	1.54	2.02	2.69	2.96
13	1.62	2.16	2.64	3.12	3.61
14	2.11	2.45	2.85	3.29	3.76
15	2.12	2.46	2.87	3.25	3.73
16	1.72	2.42	2.80	3.17	3.59
17	1.71	2.04	2.40	2.81	3.17
18	1.62	1.92	2.27	2.55	2.94
19	1.58	1.87	2.18	2.40	2.71
20	1.17	1.58	2.02	2.42	2.88
21	1.49	1.82	2.18	2.19	3.00
22	0.88	1.40	2.02	2.15	2.68
23	1.31	1.85	2.13	2.41	2.69

STATION DAY	36	37	38	39	40
MARCH					
25	4.35	4.89	5.43	6.10	6.86
26	4.25	4.84	5.41	6.04	6.86
27	4.03	4.70	5.42	6.10	6.96
28	4.40	5.12	5.77	6.52	7.49
29	4.45	4.88	5.37	5.87	6.49
30	4.71	5.35	5.88	6.45	7.07
31	5.05	5.67	6.32	6.45	7.07
APRIL					
2	5.23	5.80	6.20	6.28	6.33
3	4.09	4.75	5.38	6.02	6.88
4	3.88	4.39	4.89	5.42	6.05
5	3.57	4.10	4.64	5.25	5.86
6	3.43	4.04	4.64	5.30	5.99
7	3.55	4.16	4.73	5.29	6.03
8	3.44	4.20	4.65	5.30	5.99
9	3.51	4.23	4.75	5.33	6.05
10	3.57	4.39	4.99	5.64	6.29
11	3.72	4.43	5.02	5.76	6.43
12	3.56	4.19	4.90	5.56	6.32
13	4.21	4.84	5.38	7.94	6.64
14	4.23	4.76	5.32	5.96	6.76
15	4.53	4.73	5.21	5.74	6.41
16	4.05	4.50	4.97	5.50	6.14
17	3.60	4.07	4.57	5.12	5.80
18	3.33	3.78	4.28	4.83	5.52
19	3.04	3.50	4.04	4.82	5.62
20	3.38	3.95	4.48	5.17	5.68
21	3.52	4.06	4.66	5.24	5.99
22	3.22	4.06	4.54	5.07	6.13
23	3.12	3.72	4.43	5.27	6.09

STATION DAY	41	42	43	44	45	46
MARCH						
25	7.79	8.20	8.63	9.83	9.91	10.39
26	8.09	8.80	9.42	9.87	9.91	10.39
27	8.09	8.80	9.42	9.87	9.91	10.39
28	8.09	8.80	9.42	9.87	9.91	10.39
29	7.44	8.80	9.42	9.87	9.91	10.39
30	7.50	8.50	9.42	9.87	9.91	10.39
31	7.50	8.60	9.42	9.85	9.91	10.39
APRIL						
2	7.50	8.80	9.42	9.85	9.91	10.39
3	7.75	8.80	9.42	9.85	9.91	10.39
4	6.82	8.40	9.42	9.85	9.91	10.39
5	6.53	8.40	9.42	9.85	9.91	10.39
6	6.82	8.80	9.42	9.85	9.91	10.39
7	6.84	8.40	9.42	9.85	9.91	10.39
8	6.90	8.40	9.42	9.85	9.91	10.39
9	6.96	8.40	9.47	9.87	9.91	10.39
10	7.02	8.40	9.47	9.87	9.91	10.39
11	7.15	8.40	9.47	9.87	9.91	10.39
12	7.09	8.40	9.47	9.87	9.91	10.39
13	7.44	8.40	9.49	10.03	9.99	10.53
14	7.71	8.30	9.55	10.03	9.99	10.53
15	7.36	8.40	9.29	10.01	9.99	10.53
16	6.68	8.10	9.12	10.07	9.98	10.45
17	6.69	7.60	8.75	10.08	10.09	10.45
18	6.45	7.50	8.71	10.04	10.09	10.45
19	6.71	7.40	8.71	10.04	10.09	10.45
20	6.82	7.60	8.84	10.09	10.09	10.45
21	6.91	7.70	8.84	10.09	10.09	10.45
22	6.91	7.80	8.84	10.09	10.09	10.45
23	6.98	7.70	8.84	10.09	10.09	10.45

APPENDIX C

Daily Sand-Level Changes (in feet)

STATION DAY	1	2	3	4	5
MARCH					
25					
26	0.0	0.0	0.11	-0.04	-0.04
27	-0.02	-0.06	0.06	-0.06	-0.01
28	-0.01	0.10	-0.07	-0.01	0.05
29	-0.05	-0.25	-0.08	-0.05	-0.12
30	0.09	0.09	0.03	0.05	0.09
31	0.10	0.16	0.27	-0.02	0.01
APRIL 2	-0.13	-0.20	-0.23	0.03	0.0
3	0.10	0.08	-0.10	-0.10	-0.17
4	-0.01	-0.26	-0.39	-0.00	0.38
5	-0.10	-0.15	0.23	-0.26	-0.51
6	0.0	0.0	0.0	0.0	0.0
7	-0.00	0.29	0.15	0.29	-0.05
8	0.06	0.04	0.10	0.00	0.04
9	-0.05	0.10	0.03	0.06	0.05
10	-0.01	-0.02	-0.08	-0.07	0.13
11	-0.01	0.01	-0.02	-0.01	-0.05
12	0.02	0.04	0.02	-0.02	0.17
13	0.11	0.00	-0.06	0.00	-0.14
14	-0.03	-0.10	0.06	0.10	0.07
15	-0.04	0.06	-0.01	-0.13	-0.12
16	-0.03	-0.04	-0.01	0.06	0.0
17	0.16	0.05	0.12	0.27	0.20
18	-0.14	0.01	0.02	-0.24	-0.01
19	0.11	0.01	-0.03	0.01	0.11
20	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0
22	0.0	0.18	-0.11	0.02	-0.10
23	-0.01	-0.16	0.12	-0.08	-0.09

STATION DAY	6	7	8	9	10
March					
25	0.01	0.0	-0.04	-0.08	-0.33
26	-0.11	-0.16	-0.03	0.04	0.76
27	0.03	-0.01	0.01	-0.14	-0.52
28	0.09	0.42	-0.48	0.16	-0.07
29	-0.07	-0.42	0.54	-0.15	0.07
30	0.18	0.26	-0.04	0.07	0.10
31	-0.15	-0.29	0.0	-0.09	-0.23
April 2	-0.13	0.45	-0.54	0.21	-0.08
3	0.12	-0.62	0.18	-0.51	-0.06
4	-0.35	0.07	0.17	0.20	0.12
5	0.0	0.0	0.0	0.0	0.0
6	0.16	0.82	-0.00	1.14	0.53
7	-0.01	-0.38	-0.10	0.20	0.07
8	0.04	0.08	0.21	0.01	-0.06
9	0.03	0.0	-0.09	0.03	-0.07
10	0.09	-0.05	0.03	0.09	-0.03
11	-0.04	-0.09	-0.02	-0.03	0.26
12	-0.02	0.06	-0.05	-0.00	0.00
13	0.19	-0.03	0.13	0.15	-0.04
14	-0.26	0.0	-0.20	-0.18	-0.09
15	0.08	-0.03	-0.03	0.04	0.10
16	0.15	-0.01	0.02	-0.01	-0.01
17	0.13	0.06	0.12	-0.09	-0.19
18	-0.03	-0.01	-0.03	0.09	0.12
19	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0
21	-0.10	-0.01	0.11	0.08	0.26
22	-0.08	-0.08	-0.04	-0.08	0.11
23					

STATION DAY	11	12	13	14	15
March					
25	-0.12	-0.50	0.0	0.08	0.09
26	-0.02	0.30	-0.24	-0.50	0.05
27	0.06	-0.02	0.32	0.41	-0.13
28	-0.47	-0.29	-0.26	-0.42	-0.67
29	0.15	0.09	-0.25	0.08	0.34
30	-0.13	-0.12	0.80	-0.05	-0.14
31	-0.25	-0.23	-1.07	-0.25	-0.07
April 2	0.19	-0.14	0.06	-0.36	-0.17
3	0.85	0.64	0.72	0.29	-0.07
4	-1.18	0.87	-0.35	0.23	-0.09
5	0.0	0.0	0.0	0.0	0.0
6	0.28	-0.97	1.63	1.63	1.52
7	0.80	1.25	0.71	0.69	0.41
8	-0.40	-0.15	0.08	-0.65	-0.12
9	-0.02	-0.03	0.04	-0.17	0.07
10	-0.00	0.10	-0.09	-0.07	0.36
11	0.36	0.56	0.74	0.92	0.82
12	0.17	-0.26	-0.52	-0.59	-0.45
13	-0.37	-0.18	-0.05	-0.03	0.26
14	-0.09	0.25	-0.08	-0.07	-0.19
15	0.09	0.56	-0.16	-0.50	-1.57
16	-0.06	-0.60	0.0	0.78	1.50
17	-0.19	-0.22	0.25	0.04	0.23
18	0.0	-0.18	-0.08	0.10	-0.73
19	0.0	0.0	0.0	0.0	0.0
20	1.84	-0.49	-1.43	0.27	1.00
21	-1.08	-0.02	2.00	0.0	-0.48
22	0.03	1.57	-2.00	-0.06	0.48
23					

STATION DAY	16	17	18	19	20
March					
25	0.50	0.99	0.83	0.0	-1.08
26	-0.52	-0.80	-0.36	0.30	0.79
27	0.02	-0.40	-0.64	-0.64	-1.59
28	-0.48	-0.33	0.09	0.0	1.79
29	0.21	0.46	0.32	0.54	-1.39
30	-0.01	0.02	0.01	-0.16	0.08
31	0.26	0.11	0.06	-0.10	-0.39
April					
2	-0.36	-0.01	-0.17	0.09	0.16
3	-1.03	-1.45	-0.87	-1.09	-0.46
4	0.97	0.90	0.10	-0.50	-0.70
5	0.0	0.0	0.0	0.0	0.0
6	-0.24	-0.18	1.16	1.58	2.93
7	1.77	1.88	1.47	1.54	0.14
8	-0.31	0.30	0.17	0.03	0.93
9	-1.57	-0.70	-0.09	-0.20	0.0
10	-0.05	0.70	-0.01	0.05	-3.04
11	0.77	1.18	0.37	0.33	0.20
12	-0.46	-1.58	-0.20	-0.16	0.20
13	-0.20	0.0	0.07	0.07	2.07
14	2.23	-0.40	-0.84	-2.03	-2.60
15	-1.62	-0.40	-1.00	0.10	0.43
16	-0.28	0.27	1.74	1.88	2.84
17	-0.12	-0.72	0.19	0.13	0.80
18	-0.20	0.34	-0.73	-0.14	-1.20
19	0.0	0.0	0.0	0.0	0.0
20	1.02	0.50	0.20	0.52	0.61
21	1.57	0.02	-1.21	0.20	0.53
22	-1.30	-0.37	1.01	-0.07	-3.21
23					

STATION DAY	21	22	23	24	25
March					
25	0.42	0.41	0.09	0.18	-0.05
26	0.02	-0.10	-0.19	-0.38	-0.01
27	1.37	0.55	-0.19	-0.43	-0.54
28	-0.68	0.64	1.04	1.10	0.66
29	-0.71	-0.93	-0.62	-0.75	-0.27
30	0.03	-0.56	-0.10	0.13	0.27
31	-1.12	-0.25	-0.08	-0.04	-0.30
April					
2	0.90	0.57	0.12	0.16	0.09
3	-0.53	-0.46	-0.31	-0.24	-0.18
4	-1.67	-0.69	0.29	0.37	0.32
5	0.0	0.0	-0.01	-0.22	-0.31
6	3.22	0.31	0.29	0.11	0.46
7	0.30	0.07	-0.34	0.33	-0.14
8	0.92	0.13	0.00	-0.91	-0.33
9	-0.23	0.90	0.16	0.84	0.92
10	0.12	-0.08	-0.17	-0.34	-0.64
11	0.27	0.70	-0.20	-0.00	-0.21
12	-3.11	-0.13	0.33	-0.20	-0.69
13	0.60	-0.43	0.72	0.98	1.46
14	0.10	-0.37	-0.30	-0.31	-0.26
15	2.05	0.02	-0.11	-0.05	-0.02
16	0.27	0.37	-0.16	-0.27	-0.37
17	0.29	0.14	0.10	0.08	0.05
18	-0.10	0.05	0.31	0.35	0.32
19	0.0	0.0	0.0	0.0	0.0
20	0.10	0.23	-0.63	-0.31	-0.36
21	0.0	0.43	-0.07	-0.01	0.80
22	0.0	-0.85	0.46	0.39	-0.85
23					

STATION DAY	26	27	28	29	30
March					
25	-0.08	-0.01	0.07	0.01	-0.08
26	0.18	-0.28	0.24	0.12	-0.01
27	-0.72	-1.20	-0.88	-0.56	-0.34
28	0.39	0.0	0.06	0.02	-0.16
29	-0.74	0.11	0.29	-0.08	0.22
30	0.80	-0.39	-0.01	0.18	-0.01
31	-0.13	-0.21	-0.22	0.44	1.09
April					
2	0.03	0.57	0.32	-0.34	-0.97
3	-0.21	-0.64	-0.13	-0.07	-0.09
4	0.28	0.43	0.09	-0.03	-0.11
5	-0.36	-1.05	-0.73	-0.52	-0.25
6	0.46	0.20	0.49	0.33	0.09
7	-0.12	0.41	0.08	-0.08	-0.39
8	0.58	0.10	-0.22	0.41	1.48
9	-0.46	0.15	0.24	-0.25	-1.03
10	0.03	0.30	0.10	0.21	0.20
11	-1.00	-0.82	-0.59	-0.62	-0.57
12	-0.30	0.16	0.34	0.33	0.67
13	1.72	0.43	0.46	0.53	0.30
14	-0.12	0.52	0.29	0.09	-0.05
15	-0.01	0.32	0.0	0.05	-0.04
16	-0.41	-0.42	-0.44	-0.46	-0.33
17	-0.02	-0.08	-0.10	-0.06	-0.11
18	0.14	-0.08	0.01	-0.04	-0.03
19	0.0	-0.34	-0.17	-0.30	-0.30
20	-0.01	0.23	0.03	0.20	0.18
21	-0.14	-0.75	-1.90	-0.20	-0.25
22	-0.03	0.69	1.71	-0.03	0.15
23					

STATION DAY	31	32	33	34	35
March					
25	-0.10	-0.35	-0.17	-0.05	-0.05
26	-0.15	-0.07	-0.75	-0.25	-0.26
27	0.05	0.08	0.80	0.23	0.30
28	-0.25	-0.14	0.04	0.15	0.11
29	0.12	0.03	-0.04	-0.10	0.11
30	-0.16	-0.55	-0.29	-0.02	0.19
31	-0.04	1.00	0.29	-0.23	-0.52
April					
2	0.26	-0.44	-0.08	0.05	-0.11
3	-0.08	-0.09	-0.10	-0.15	-0.19
4	-0.11	-0.51	-0.22	-0.21	-0.30
5	-0.28	0.11	-0.25	-0.25	-0.18
6	0.20	0.17	0.16	0.15	0.19
7	-0.25	-0.45	-0.58	-0.30	-0.28
8	-0.13	0.02	0.42	0.18	0.11
9	0.28	0.22	0.02	0.09	-0.09
10	0.10	0.20	0.10	-0.10	0.17
11	-0.63	-0.39	-0.23	0.14	-0.08
12	0.65	0.61	0.62	0.43	0.65
13	0.49	0.29	0.21	0.17	0.15
14	0.01	0.01	0.02	-0.03	-0.03
15	-0.40	-0.05	-0.08	-0.09	-0.13
16	-0.01	-0.38	-0.39	-0.35	-0.43
17	-0.10	-0.11	-0.13	-0.26	-0.23
18	-0.04	-0.06	-0.09	-0.15	-0.23
19	-0.40	-0.29	-0.16	0.02	0.17
20	0.32	0.24	0.16	-0.24	0.12
21	-0.61	-0.42	-0.16	-0.03	-0.32
22	0.43	0.44	0.11	0.26	0.01
23					

STATION DAY	36	37	38	39	40
March					
25	-0.10	-0.06	-0.02	-0.06	0.0
26	-0.22	-0.13	0.01	0.06	0.09
27	0.37	0.42	0.35	0.42	0.53
28	0.05	-0.25	-0.40	-0.65	-1.00
29	0.25	0.48	0.51	0.57	0.57
30	0.34	0.32	0.44	0.0	0.0
31	0.18	0.13	-0.12	-0.17	-0.73
April					
2	-1.14	-1.05	-0.82	-0.26	0.55
3	-0.21	-0.35	-0.49	-0.60	-0.83
4	-0.31	-0.29	-0.26	-0.16	-0.19
5	-0.14	-0.06	0.0	0.05	0.12
6	0.12	0.12	0.10	-0.01	0.04
7	-0.11	0.04	-0.08	0.01	-0.04
8	0.08	0.02	0.10	0.02	0.07
9	0.06	0.16	0.24	0.31	0.24
10	0.15	0.05	0.04	0.11	0.14
11	-0.16	-0.24	-0.12	-0.20	-0.10
12	0.65	0.65	0.48	2.38	0.32
13	0.02	-0.08	-0.06	-1.98	0.12
14	0.30	-0.03	-0.10	-0.22	-0.35
15	-0.48	-0.23	-0.24	-0.24	-0.27
16	-0.44	-0.44	-0.40	-0.38	-0.35
17	-0.27	-0.29	-0.29	-0.29	-0.28
18	-0.29	-0.28	-0.24	-0.02	0.10
19	0.34	0.45	0.44	0.35	0.07
20	0.14	0.11	0.18	0.07	0.31
21	-0.30	-0.01	-0.12	-0.16	0.13
22	-0.10	-0.34	-0.11	0.20	-0.03
23					

STATION DAY	41	42	43	44	45	46
March						
25	0.30	0.60	0.79	0.05	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0
28	-0.66	0.0	0.0	0.0	0.0	0.0
29	0.06	-0.30	0.0	0.0	0.0	0.0
30	0.0	0.10	0.0	-0.02	0.0	0.0
31	0.0	0.20	0.0	0.0	0.0	0.0
April						
2	0.25	0.0	0.0	0.0	0.0	0.0
3	-0.93	-0.40	0.0	0.0	0.0	0.0
4	-0.29	0.0	0.0	0.0	0.0	0.0
5	0.29	0.40	0.0	0.0	0.0	0.0
6	0.02	-0.40	0.0	0.0	0.0	0.0
7	0.06	0.0	0.0	0.0	0.0	0.0
8	0.07	0.0	0.05	0.02	0.0	0.0
9	0.06	0.0	0.0	0.0	0.0	0.0
10	0.13	0.0	0.0	0.0	0.0	0.0
11	-0.07	0.0	0.0	0.0	0.0	0.0
12	0.36	0.0	0.01	0.15	0.08	0.14
13	0.27	-0.10	0.07	0.0	0.0	0.0
14	-0.35	0.10	-0.26	-0.02	0.0	0.0
15	-0.68	-0.30	-0.16	0.06	-0.01	-0.08
16	0.01	-0.50	-0.38	0.01	0.11	0.0
17	-0.24	-0.10	-0.04	-0.04	0.0	0.0
18	0.27	-0.10	0.0	0.0	0.0	0.0
19	0.11	0.20	0.13	0.05	0.0	0.0
20	0.09	0.10	0.0	0.0	0.0	0.0
21	0.0	0.10	0.0	0.0	0.0	0.0
22	0.07	-0.10	0.0	0.0	0.0	0.0
23						

APPENDIX D

Daily Median Diameter Values in Phi Units

STATION	DATE							
	March							April
	25	26	27	28	29	30	31	1
101			2.400	2.358	2.252	2.690	2.265	
1	2.251	2.251	2.218	2.089			1.826	
3		2.786			2.077			2.029
5	1.713	.837		1.862	2.000	1.943	1.561	
7					2.152			1.852
9	1.761	2.059	1.713	1.889		1.862	1.811	
11					2.044			
13	2.184	2.029		2.218	2.218	1.971	1.776	1.997
15						2.089		
17				1.599	2.171		2.029	2.184
19						2.286		
21	1.971	1.943	1.184	1.786	1.916	2.218	2.120	2.184
23						2.089		
25	1.943	1.690	1.667	1.811	2.000	2.059		2.059
27								
29	2.089	1.811	1.599	1.786	1.644	1.621	1.713	2.184
31								
33	2.184	2.029	2.077	1.943	2.089	2.218		1.548
35					1.997	2.184		
37	2.029	1.786	1.943	1.916			1.889	2.184
39								
41	1.621	2.000	1.905	2.000			2.000	
43								
45	2.434	1.621	1.862				1.943	

STATION	DATE							
	April							
	2	3	4	5	6	7	8	9
101	2.556	2.336	2.514			2.419	2.396	2.321
1		2.252	2.252	2.231		2.272	2.272	2.286
3	1.971							
5	1.837	1.761	1.737	1.889		2.089	1.811	1.989
7								
9	1.994	1.884				2.184	2.058	2.184
11								
13	2.000	2.017					1.811	1.916
15	2.184							
17		2.089					1.837	1.786
19	2.171							
21		1.704	-.379	2.029	1.667	1.852	2.000	1.943
23	2.114							
25		1.862	1.599		1.718	2.029	1.889	1.690
27								
29	2.053	1.916	1.494		1.657	1.786	1.666	1.690
31								
33	2.120	2.029	1.837		1.837	2.000	1.689	1.578
35								
37	2.089	2.184	2.029		1.900	1.971	1.690	1.680
39								
41		1.905	1.800		1.816	1.836	1.786	1.852
43								
45								

STATION	DATE							
	April							
	10	11	12	13	14	15	16	17
101	2.252	2.322	2.419	2.322	2.286	2.396	2.322	2.450
1	1.727	2.184	2.252	2.238	2.191	2.218	2.322	2.308
3								
5	1.943	1.837	2.000	2.077	2.000	1.556	1.916	1.889
7								
9	2.152	2.184	1.862	2.120	1.889	1.591	2.152	2.133
11								
13	1.889	1.690	2.218	2.071	2.388	1.826		1.358
15								
17	1.943	1.916	2.252	1.761	1.599	1.680	1.761	1.713
19								
21	.667	1.971			1.434	1.690	1.713	1.577
23								
25	1.690	1.916	1.852	1.837				
27								
29	1.184	1.415	1.690	1.943	1.826	2.114	2.152	2.120
31								
33	1.786	1.535						
35								
37	1.786	1.667	1.713		2.029		1.816	1.943
39								
41	1.811	1.751						
43								
45							1.785	1.713

STATION	DATE					
	April 18	19	20	21	22	23
101		2.286			2.300	2.252
1		2.218			2.286	2.252
3						
5		1.761			1.862	
7						
9		2.152		1.927	2.120	1.889
11						
13	2.108	2.035		2.152	1.690	1.761
15						
17	2.029	1.556		2.000	1.737	1.771
19						
21	1.713	1.667		1.796	2.059	1.786
23						
25	1.921		1.801			
27		.425			1.514	
29	2.059	1.494	1.921	1.723	1.786	1.821
31						
33	1.900		1.786			
35						
37	1.905	1.786	1.837	1.943	1.837	1.862
39						
41	1.761		1.862	1.713		
43						
45						

APPENDIX E

Daily Standard Deviation Values in Phi Units

STATION	March 25	26	27	28	29	30	31	April 1
101			.422	.444	.573	.552	.447	
1	.411	.397	.322	.356			.444	
3		.482			.375			.450
5	.404	.414		.424	.464	.434	.565	
7					.399			.695
9	.418	.392	.404	.442		.461	.482	
11					.469			
13	.347	.865		.437	.443	.441	.509	.454
15						.458		
17				.424	.412		.420	.353
19						.368		
21	.645	.641	.688	.824	.519	.350	.437	.513
23						.669		
25	.490	.483	.662	.876	.450	.576		.665
27								
29	.337	.455	.576	.482	.640	.725	.583	.445
31								
33	.286	.510	.417	.461	.431	.391		.571
35					.473	.306		
37	.329	.544	.432	.462			.636	.360
39								
41	.450	.509	.422	.412				
43								
45	.415	.433	.396				.801	

STATION	DATE							
	April 2	3	4	5	6	7	8	9
101	.427	.466	.565			.491	.503	.473
1		.500	.435	.411		.457	.433	.474
3	.470							
5	.445	.455	.437	.422		.337	.444	.470
7								
9	.480	.509				.310	.439	.344
11								
13	.467	.451					.784	.401
15	.533							
17		.451					.563	.635
19	.572							
21		.899	2.006	.452	.497	.509	.461	.509
23	.680							
25		.560	-.289		.500	.348	.451	.594
27								
29	.519	.525	.873		.518	.445	.292	.621
31								
33	.372	.412	.424		.472	.357	.372	1.561
35								
37	.406	.365	.398		.446	.302	.417	.292
39								
41		.625	.379		.386		.436	.387
43								
45								

STATION	DATE							
	April 10	11	12	13	14	15	16	17
101	.212	.486	.474	.514	.486	.453	.455	1.280
1	.371	.424	.416	.450	.231	.359	.418	.413
3								
5	.430	.500	.450	.424	.441	.354	.433	.473
7								
9	.313	.326	.368	.441	.428	.339	.381	.331
11								
13	.452	.534	.320	.426	.446	.639		.993
15								
17	.471	.441	.460	.665	.952	.577	.518	.485
19								
21	.251	.510			.887	.420	.518	.395
23								
25	.508	.481	.345	.404				
27								
29	1.142	.733	.738	.416	.379	.381	.292	.286
31								
33	.553	.957						
35								
37	.428	.214	.417		.398		.307	.316
39								
41	.406	.376						
43								
45							.420	.413

STATION				DATE		
	April 18	19	20	21	22	23
101		.481			.258	.417
1		.414		.341	.408	.368
3						
5		.457			.424	
7						
9		.306		.379	.307	.422
11						
13	.404	.379		.306	.508	.518
15						
17	.538	.892		.455	.465	.561
19						
21	.483	.698		.467	.420	.469
23						
25	.361		.491			
27		1.607			1.292	
29	.411	1.158	.412	.385	.484	.485
31						
33	.432		.430			
35						
37	.098	.436	.351	.323	.404	.375
39						
41			.406			
43						
45	.392					.392

APPENDIX F

Daily Skewness Values in Phi Units

STATION	DATE							
	March							April
	25	26	27	28	29	30	31	1
101			.238	.194	.020	-.031	.279	
1	.182	.223	.324	.079			.117	
3		.113			-.498			-.099
5	.168	2.589		.084	.021	-.128	-.118	
7								.344
9	.172	.058	.168	.062	-.331	.157	.061	
11					-.084			
13	.072	-.576		.188	-.138	-.037	.073	-.036
15						-.070		
17				-.055	-.168		-.126	-.401
19						.223		
21	-.266	-.234	.103	-2.130	-.075	.217	-.191	-.588
23						-.425		
25	.167	.164	-.011	-.332	-.034	-.279		-.315
27								
29	.025	.046	-.041	.113	-.051	-.083	-.017	-.164
31								
33	.156	-.205	-.144	-.018	-.107	.091	.411	.393
35					-.190	.213		
37	.133	-.014	-.040	-.042				.033
39								
41	.178	-.233	.074				-.076	
43								
45	.095	.226	.070				.052	

STATION	DATE							
	April 2	3	4	5	6	7	8	9
101	-.094	.254	.140			.255	.271	.199
1		.069	.228		.301	.304	.304	.161
3	-.015							
5	.140	.155	.177			.025	.151	-.052
7	-.083							
9		.006				.065	-.145	-.158
11								
13	.014	.102					.243	-.248
15	-.138							
17		-.057					-.099	-.098
19	-.401							
21		-.288	.278		.096	-.005	-.141	-.112
23	-.494							
25		-.061	-3.501		.067	.053	.124	-.112
27								
29	-.013	-.041	-.247		.043	.124	-.240	-.203
31								
33	-.156	-.147	.145		.028	.066	.159	-.632
35								
37	-.151	-.357	-.079		.028	.354	.033	.093
39								
41		.409	.190		.219	.166	.149	.214
43								
45								

STATION	DATE							
	April 10	11	12	13	14	15	16	17
101	-.320	.279	.178	.210	.352	.257	.293	.462
1	.318	.303	.167	.109	.051	.315	.230	.255
3								
5	.052	.044	-.034	.032	-.102	.140	.073	.039
7								
9	.159	.013	1.000	.186	.184	.207	.173	.029
11								
13	.038	.053	.058	-.055	-.914	-.201	.083	-.383
15								
17	-.039	.089	-.602	-.157	-.379	-.009	.108	.083
19								
21	.132	-.092			-.186	.211		.218
23								
25	.039	-.002	-.486	.202				
27								
29	-.383	-.037	-.191	-.002	.177	.272	.101	.098
31								
33	.035	-.287						
35								
37	.088	.291	.020		-.079		.742	.197
39								
41	.170	.714	.714				.191	.141
43								
45								

STATION	DATE					
	April 18	19	20	21	22	23
101		.230			-.360	.329
1		.141		.197	.298	.240
3						
5		.119			.084	
7						
9		.053		.137	.075	.113
11						
13	-.093	-.148		.053	.039	.083
15						
17	-.247	-.354		-.130	.107	-.017
19						
21	-.025	-.171		.127	-.197	.002
23						
25	.170		.061			
27		-.037			-.531	
29	-.086	-.432	.062	.200	-.309	.032
31						
33	.062		.005			
35						
37	-2.575	.149	.202	.286	.203	.129
39						
41	.165		-.141	-.173		
43						
45						

APPENDIX G

Daily Kurtosis Values in Phi Units

STATION	DATE							
	March 25	26	27	28	29	30	31	April 1
101			.763	.687	.458	.691	1.000	
1	.696	.839	1.175	1.300			.589	.896
3					.946			
5	.843	.645		.630	.964	.793	-.525	
7					.988			.159
9	.704	.928	.876	.562		.937	.585	
11					.934			
13	.875	.813		.644	.766	.872	.706	.747
15						.940		
17				4.688	.763		.888	1.270
19						1.016		
21	.915	1.042	.585	1.651	1.071	1.750	1.214	1.323
23						.926		
25	.602	.539	.823	.761	.986	.874		.822
27								
29	.519	1.021	.852	.728	.736	.525	.784	.842
31								
33	.665	.719	.390	.953	.779	.956		.466
35					.766	1.242		
37	.643	.894	1.005	1.177			-.001	.867
39								
41	.888	.120	.652	.492				
43								
45	.344	.444	.499				.342	

STATION	DATE							
	April 2	3	4	5	6	7	8	9
101	1.073	1.017	.735			.904	.786	.589
1		.796	.950		.648	1.266	1.123	.779
3	.962							
5	.798	.691	1.49			1.427	1.149	.750
7								
9	.770	.685				1.515	1.248	1.134
11								
13	.824	.870					.544	1.044
15	.703							
17		.890					1.198	1.395
19	.659							
21		.462	.113		1.046	.881	1.121	.973
23	4.307							
25		.988	-1.143		1.097	1.083	.758	1.141
27								
29	.649	.567	.461		1.309	.601	2.912	1.298
31								
33	.775	.941	1.166		1.027	.885	1.268	.417
35								
37	.908	.940	.535		.688	1.031	1.206	.913
39								
41		-.045	1.184		.783	.807	1.485	.579
43								
45								

STATION	DATE							
	April 10	11	12	13	14	15	16	17
101	2.450	.893	.985	.818	.871	.786	.985	.565
1	.982	1.005	.856	.890	1.855	1.500	.738	.894
3								
5	.740	.741	.776	1.086	.781	1.530	.759	.646
7								
9	1.533	1.647	1.125	1.478	.629	1.529	1.262	1.314
11								
13	.675	.994	1.229	.668	1.078	1.129		.580
15								
17	.826	.718	1.526	.911	.655	.941	.915	1.235
19								
21	4.248	.896	1.720		.661	1.065	1.057	1.274
23								
25	1.035	.974	.879	.688				
27								
29	.476	.600		.708	.536	.604	.868	1.248
31								
33	1.182	.916	.873					
35								
37	.733	1.300			.501		.822	1.025
39								
41	.742	.302						
43								
45							.997	.765

STATION	DATE					
	April 18	19	20	21	22	23
101		.887			2.599	.899
1		.964		1.206	1.046	1.151
3						
5		.667			.694	
7						
9		1.175		.871	1.449	.576
11						
13	1.018	.990		1.478	1.359	.186
15						
17	.849	1.054		.904	1.330	1.306
19						
21	1.586	1.070		.588	.748	1.098
23						
25	.769		.586			
27		.362			.526	
29	.800	.543	.667	.768	1.816	1.092
31						
33	.569		.464			
35						
37	5.422	.672	.585	.618	.648	.650
39						
41	.578		1.093			
43						
45						

APPENDIX H

Tide Maxima and Minima

DATE

	*1	*2	1	2	1	2	1	2
March								
25	1.8	0200	4.9	0730	-.7	1430	4.1	2130
26	1.4	0230	4.7	0830	-.4	1500	4.3	2130
27	1.0	0330	4.6	0930	-.1	1530	4.4	2200
28	.7	0400	4.3	1000	.5	1630	4.6	2230
29	.5	0430	4.2	1130	1.2	1630	4.8	2230
30	.5	0530	3.9	1130	1.6	1630	5.0	2330
31	.5	0630	3.7	1230	2.2	1730	5.1	2330
April								
1			.8	0730	3.8	1400	2.9	1800
2	5.2	0000	.6	0800	3.2	1500	2.8	1830
3	4.6	0030	.3	0930	0.0	1500		
4	4.4	0130	.2	0930				
5	3.2	0200	.3	1030	3.4	2000	3.3	2200
6	4.2	0330	-.1	1200	3.4	1930	3.0	2330
7	4.2	0430	-.1	1230	3.8	2000		
8	2.7	0030	4.5	0600	-.1	1300	4.0	2030
9	2.2	0130	4.7	0700	-.2	1400	4.3	2030
10	1.6	0200	4.8	0800	.1	1430	4.8	2030
11	1.0	0230	4.9	0830	.3	1500	5.4	2130
12	.4	0330	4.8	0930	.8	1530	5.7	2130
13	-.6	0430	4.3	1030	1.2	1600	6.1	2230
14	-.7	0530	4.0	1200	1.8	1630	6.3	2330
15	-1.0	0600	3.8	1230	2.2	1730	6.0	2400
16	-1.1	0730	3.4	1430	2.4	1800		
17	5.7	0030	-1.1	0830	3.3	1530	2.8	1900
18	5.3	0130	- .9	0930	3.5	1700	3.1	2030
19	4.9	0230	- .8	1100	3.8	1800	3.0	2230
20	4.7	0400	- .4	1200	4.0	1830	2.4	2400
21	4.4	0500	- .4	1230	4.1	1900		
22	1.8	0030	4.0	0600	-.3	1300	4.2	1930
23	1.1	0130	3.9	0730	0.0	1400		

*1 Height in feet relative to MLLW

*2 Time is Pacific Standard Time

APPENDIX I

Average Values of Median Diameter, Standard Deviation,

Skewness, and Kurtosis by Stations

(in Phi Units)

STATION	Md_ϕ	σ_ϕ	α_ϕ	β_ϕ
101	2.368	.495	.165	.975
1	2.196	.402	.214	1.050
3				
5	1.820	.439	.166	.082
7				
9	1.981	.392	.106	1.042
11				
13	1.970	.501	-.083	.083
15				
17	1.868	.537	-.129	1.213
19				
21	1.700	.633	-.004	1.206
23				
25	1.844	.501	-.215	.700
27				
29	1.792	.543	-.043	.846
31				
33	1.899	.523	-.031	1.134
35				
37	1.897	.378	.002	.951
39				
41	1.837	.424	.111	.690
43				
45	1.893	.469	.129	.565

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13. ABSTRACT

Beach-elevation measurements were made and sand samples were collected daily along a profile extending from the back of the beach out to a water depth of approximately 23 feet. Wave and tide data were measured continuously at the site. The beach is well sheltered, and low swell parallel to the beach predominates.

Offshore-onshore movement of the plunge point by the tides exerts a large influence on the textural parameters which move on and off shore with the moving plunge point. The magnitude of textural parameter values increases with decreasing wave steepness. It appears that transport of large sand grains by wave and tide action produces the observed textural patterns.

Profile changes are greatest during mid-tide stages when the water level and position of the plunge point are changing rapidly.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Beach Profile						
Beach Profile Slope						
Breaker Zone						
Kurtosis						
Median Diameter						
Plunge Point						
Sand						
Sand Texture						
Sediment						
Skewness						
Sorting						
Wave Steepness						

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